Impact of Earthquakes on the Central USA

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Mid-America Earthquake Center
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New Madrid Seismic Zone
Catastrophic Earthquake Response Planning Project

Final Phase I Report

Impact of Earthquakes on the Central USA

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Disclaimer

The assessments, comments and opinions in this report are those of the authors and do not necessarily represent the opinions of the Federal Emergency Management Agency or the US Army Corps of Engineers.

Scenario Disclaimer

The scenarios employed in this report have been selected following discussions with regional and local experts, and recommendations from the Scenario Development Workgroup formed in March 2007. These scenarios are intended to provide credible worst case impacts for individual states. They are not meant to negate or diminish the relevance of previous or future scenarios used in other studies. The Central United States is vulnerable to a number of possible credible scenarios, and it is likely that the damage and loss estimates presented in this report are different from other credible scenarios in the New Madrid Seismic Zone (NMSZ), the Wabash Valley Seismic Zone (WVSZ) and the East Tennessee Seismic Zone (ETSZ). Neither these scenarios, nor others, should be considered definitive. They represent only possible earthquakes and corresponding damage and loss for the eight states considered hereafter. Various models and methods of representing damage to infrastructure, shelter requirements, casualties, and economic losses are employed in the simulated earthquake impact process and lead to different results according to different modeling assumptions. Also, the social impact models used throughout this study have not been calibrated to observations from catastrophic events, but rather damaging earthquakes, solely in California. Furthermore, the availability of datasets to characterize state infrastructure changes with time. For example, population estimates and numbers of buildings are likely to be different based on the year in which the scenario is created and the access allowed by owners of datasets to the detailed inventory. The sensitivity (vulnerability) of assets to earthquake shaking may be evaluated in many different ways, and different methods are likely to lead to different levels of vulnerability. Finally, seismological (hazard) and geotechnical (site soil) effects, such as liquefaction, significantly affect the estimated impact. Characterizing seismological hazard and soil effects is non-unique; hence, assumptions concerning such effects made in other studies may lead to impact estimates that are different from those presented hereafter. When considering the above sources of uncertainty in the development of scenarios (inventory, vulnerability and hazard, respectively) no single scenario should be considered to be an exact depiction of impacts in a state but rather as a plausible estimate of a state's damage and loss.

Additional scenarios outside of the NMSZ are considered for the States of Alabama and Indiana. An ETSZ earthquake is employed for Alabama and a WVSZ event is employed for Indiana and Illinois. The ETSZ hazard was approved by the State of Alabama Geological Survey while the hazard data for the WVSZ scenario was provided by the U.S. Geological Survey (USGS). These additional scenarios represent possible events in the two seismic zones, and others may be investigated. Other scenarios are expected to provide different damage and loss estimates based on the aforementioned factors in seismic impact assessment modeling; i.e., inventory, vulnerability, and hazard. Finally, all numbers in this report should be viewed as indicative of the possible impact provided for the purposes of emergency response planning rather than as definitive figures of expected impact. The uncertainty associated with all numbers provided in this and other earthquake impact assessment reports is considerable. At the current state of knowledge of hazard, fragility, inventory and aggregation of losses, it is not possible to quantify the level of uncertainty associated with the impacts provided in this report.

Executive Summary

The region of potential impact due to earthquake activity in the New Madrid Seismic Zone (NMSZ) is comprised of eight states: Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri and Tennessee. Moreover, the Wabash Valley Seismic Zone (WVSZ) in southern Illinois and southeast Indiana and the East Tennessee Seismic Zone in eastern Tennessee and northeastern Alabama constitute significant risk of moderate-to-severe earthquakes throughout the central region of the USA. The investigation summarized in this report includes earthquake impact assessment scenarios completed using HAZUS-MH MR2 for several potential earthquake scenarios affecting the aforementioned eight-state region. The NMSZ includes eight scenarios - one for each state - whilst the WVSZ scenario in Indiana and the ETSZ scenario in Alabama complete the suite of ten total scenarios. These ten scenarios are designed to provide scientifically-credible, worst case damage and loss estimates for the purposes of emergency planning, response and recovery.

The earthquake impact assessments presented in this report employ an analysis methodology comprising three major components; namely hazard, inventory and fragility (or vulnerability). The **hazard** characterizes not only the shaking of the ground but also the consequential transient and permanent deformation of the ground due to strong ground shaking. The **inventory** comprises all assets in a specified region, including the built environment and population data. Fragility or vulnerability functions relate the severity of shaking to the likelihood of reaching or exceeding damage states (light, moderate, extensive and near-collapse, for example). Social impact models are also included in the current assessment methodology and employ infrastructure damage results to estimate the effects on populations subjected to the earthquake. Whereas the modeling software used (HAZUS-MH MR2, FEMA-NIBS, 2006) provides default values for all of the above, most of these default values were replaced by components of traceable provenance and higher reliability than the default data, as described below.

The hazard employed in this investigation includes ground shaking for three seismic zones and various events within those zones. The NMSZ consists of three fault segments: the northeast segment, the reelfoot thrust or central segment, and the southwest segment. Each segment comprises a deterministic, magnitude 7.7 (M_w7.7) earthquake caused by a rupture over the entire length of the segment. The employed magnitude was provided by US Geological Survey (USGS). The NMSZ represents the first of three hazard events utilized in this report. Two deterministic events are also included, namely a magnitude M_w7.1 in the Wabash Valley Seismic Zone (WVSZ) and a magnitude M_w5.9 in the East Tennessee Seismic Zone (ETSZ) earthquakes. Permanent ground deformation is characterized by a liquefaction susceptibility map that provides data for part of the eight states. Full liquefaction susceptibility maps for the entire region are still under development and will be utilized in subsequent phases of the current project.

Inventory is enhanced through the use of the Homeland Security Infrastructure Program (HSIP) 2007 Gold Dataset (NGA Office of America, 2007). This dataset contains various

types of critical infrastructure that are key inventory components for earthquake impact assessment. Transportation and utility facility inventories are improved while regional natural gas and oil pipelines are added to the inventory, alongside some high potential loss facility inventories. Additional essential facilities data were used for the State of Illinois via another impact assessment project at the Mid-America Earthquake Center, funded by FEMA and the Illinois Emergency Management Agency. Existing HAZUS-MH MR2 fragility functions are utilized in this study and default values are used to determine damage likelihoods for all infrastructure components.

The results indicate that the State of Tennessee incurs the highest level of damage and social impacts. Over 250,000 buildings are moderately or more severely damaged, over 260,000 people are displaced and well over 60,000 casualties (injuries and fatalities) are expected. Total direct economic losses surpass $56 billion. The State of Missouri also incurs substantial damage and loss, though estimates are less than those in Tennessee. Well over 80,000 buildings are damaged leaving more than 120,000 people displaced and causing over 15,000 casualties. Total direct economic losses in Missouri reach nearly $40 billion. Kentucky and Illinois also incur significant losses with total direct economic losses reaching approximately $45 and $35 billion, respectively. The State of Arkansas incurs nearly $19 billion in direct economic loss while the State of Mississippi incurs $9.5 billion in direct economic losses. States such as Indiana and Alabama experience limited damage and loss from NMSZ events with approximately $1.5 and $1.0 billion, respectively. Noting that experience confirms that the indirect economic loss due to business interpretation and loss of market share, amongst other features, is at least as high if not much higher than the direct economic losses, the total economic impact of a series of NMSZ earthquakes is likely to constitute by far the highest economic loss due to a natural disaster in the USA.

The contents of this report provide the various assumptions used to arrive at the impact estimates, detailed background to the above figures, and a breakdown of the figures per sector at the county and state levels. The main body of the report gives state-level impact assessments, whilst the Appendices give earthquake impact modeling results at the county level. The results are designed to provide emergency managers and agencies with information required to establish response plans based on likely impacts of plausible earthquakes in the central USA.

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Introduction

Catastrophic event response planning assessments are underway, led by the Federal Emergency Management Agency (FEMA). The effort focuses on plausible natural disasters that could impact the nation. Examples of these catastrophic events include a significant earthquake in Los Angeles, California, a Category V hurricane in Miami, Florida, and a magnitude 7.7 earthquake in the New Madrid Seismic Zone (NMSZ).

The Mid-America Earthquake Center (MAEC) at the University of Illinois and the Institute for Crisis, Disaster and Risk Management (ICDRM) at the George Washington University in Washington, D.C., were contracted by FEMA through the U.S. Army Corps of Engineers to study earthquake consequences in the Central USA. This project comprises a multi-phase investigation of possible earthquake scenarios, analytical earthquake impact assessments, and social impact estimates that will assist federal, state, and local governments to develop coordinated response plans for a catastrophic earthquake in Central USA. The primary objective of this multi-phase project is to provide scientifically defensible earthquake impact assessments with the most up-to-date hazard, inventory and fragility data in order to save lives and protect property. Current social impact modeling uses the earthquake impact assessment results to create the best available estimates of affected population and the various requirements for the care of displaced residents. The Project Team has concluded the first phase of the earthquake impact assessments which are the preliminary estimates of direct damage to infrastructure, social impacts and economic losses for the individual states (reference is made to the Scenario Disclaimer above). The results of this Phase were utilized in numerous earthquake response and recovery planning workshops at the local and state-level by the eight Central US Earthquake Consortium (CUSEC) member states. The CUSEC member states are: Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri and Tennessee. This report details components of impact for all analyses completed for response planning. The reported impact assessment estimates are compared with other limited impact assessment studies available for the NMSZ.

Earthquake Impact Assessment Overview

Analytical earthquake impact assessments require three fundamental components; namely *hazard*, *inventory* and *fragility*. The hazard includes a definition of ground motion and consequential ground effects, such as large permanent ground deformation. Inventory is a compilation of assets in a specific region of interest, and may include numerous types of infrastructure in the built environment as well as population demographic data. Fragility relationships relate a certain level of ground shaking to the likelihood of a specified degree of damage. These three parameters are integrated to determine direct damage, direct economic loss and functionality of infrastructure components. The results of this direct damage assessment are then used to determine social impacts such as displaced population and sheltering requirements. The three primary components and social impacts are explained in further detail in the following sections of the report.

Hazard

The earthquake hazard experienced by a certain region of interest, such as a state, may be defined by several methods and with varying degrees of detail. A minimum definition of hazard requires the level of shaking be quantified over the entire region of interest, expressed as peak ground motion parameters (acceleration, velocity and displacement). The hazard may also be expressed as peak response of simple structures (peak spectral values: peak spectral acceleration, velocity and displacement). One method to estimate shaking is through the use of attenuation functions. Regionally appropriate attenuation functions are available, such as attenuations for Europe (Ambraseys and Bommer, 1991; Ambraseys and Bommer, 1992; Ambraseys and Simpson, 1996), Japan (Fukushima et al., 1995; Kamiyama, 1995), the Western U.S. (WUS) (Abrahamson and Silva,1997; Atkinson and Boore, 2002; Campbell and Bozorgnia, 2003), and the Central and Eastern U.S. (CEUS) (Atkinson and Boore, 1995; Toro et al., 1997; Sommerville et al., 2001). Attenuations relationships, by definition, illustrate the propagation of shaking from a point source, commonly referred to as an epicenter (or in some cases, hypocenter[1]). More comprehensive source modeling is available to better characterize the ground shaking that results from an earthquake. Line-source modeling involves the rupture of an entire fault segment and may account for directionality of fault rupture in the estimation of ground motion. By including more aspects of ground motion, line-source modeling is preferred over a more simplified point-source model. Area source models also exist, and require considerable knowledge of the tectonic environment and mapping of fault geometry and likely mechanisms of rupture.

Numerous additional components are required for a complete definition of hazard. Soil amplification is used to adjust the ground motion for local soil conditions since different soil type affect the surface shaking nature. For example soft soil deposits are likely to filter short period vibrations and amplify long period shaking, thus increasing the likelihood of damage to long-period structures such as high-rise buildings and long-span bridges. Liquefaction susceptibility refers to the change in phase of partially saturated soil deposits that may completely lose cohesion during prolonged shaking. This results in permanent ground deformations such as lateral spreading and settlement, both of which increase the likelihood of damage to infrastructure. Landslide susceptibility is included in earthquake impact assessments to define the likelihood of inclined deposits sliding during or shortly after earthquakes. Additional forms of hazard definition include surface fault rupture, though this is not discussed here. Hazard characterization for this project is mainly based on the U.S. Geological Survey studies, supported and augmented by information from the state geological surveys in the eight affected states. For more information on hazard definition in earthquake impact assessment, please refer to Appendix IV.

[1] The hypocenter is the location in the earth where the source of rupture is located. The epicenter is the projection of the hypocenter on the Earth's surface. Conversely, the hypocenter is located beneath the epicenter at a specific distance, called the 'focal depth.' For further information please reference the HAZUS-MH MR2 Technical Manual, Chapter 4, Figure 4.3 for an illustration of this concept.

Inventory

Inventory includes all components of the built environment as well as demographic data. Demographic data includes estimates of total population, and various group classifications within the general population, broken down by income, ethnicity, education and age. Inventory, or assets, in the built environment includes a wide variety of infrastructure with commonly used inventory types listed below:

- Essential Facilities
  - Schools and Hospitals
  - Police and Fire Stations
  - Emergency Operation Centers (EOCs)
- Transportation Lifelines
  - Highway Bridges and Roads
  - Railway Bridges, Tracks and Facilities
  - Airport, Port, Bus and Ferry Facilities
- Utility Lifelines
  - Potable Water Facilities and Networks
  - Waste Water Facilities and Networks
  - Natural Gas Facilities and Pipelines
  - Oil Facilities and Pipelines
  - Electric Power and Communication Facilities
- High Potential-Loss Facilities
  - Dams and Levees
  - Hazardous Materials Plants
  - Nuclear Power Plants

Various types of information, or metadata, are required for a full assessment of these components. A description of building type, construction material, height, age, design level and soil condition is required to determine the response of the building to ground shaking. A replacement value must also be included if direct economic losses are to be determined. Many of the aforementioned infrastructure items are packaged with the impact assessment software, HAZUS-MH MR2, as default data. Updates to this baseline, or default, inventory will improve the accuracy of the impact assessment as more of the actual inventory is captured in the assessment. Additionally, new types of inventory may be added to address site-specific issues. Such inventory items can include high-rise buildings, long-span bridges, cell phone towers, arenas and stadiums, historical landmarks, and mass public transit such as subways and elevated rail systems, among others. The majority of the inventory data used for this project is taken primarily from the Homeland Security Infrastructure Program (HSIP) 2007 dataset, with additional inventory collected by the MAE Center for specific regions[2]. For more information on inventory for earthquake impact assessment, please refer to Appendix IV.

[2] Many bridges are included in the default inventory provided by HAZUS-MH MR2, though these bridges do not include major river crossings, such as those over the Mississippi and Missouri Rivers. These bridges have unique structural configurations that require structure-specific analyses

Fragility

Fragility functions are used to relate the intensity of ground shaking to the likelihood of a particular level of damage occurring. Fragility functions, sometimes referred to as vulnerability functions, when represented graphically plot a shaking intensity (or hazard) parameter against a probability that a given damage level (e.g. light, moderate or severe) will occur. In other words, if a certain level of shaking is experienced by a structure, a fragility function will estimate how likely it is that this particular structure will incur various levels of damage. Numerous parameters are used to quantify the level of shaking and may include peak ground acceleration (PGA), velocity (PGV) or displacement (PGD). Also, the maximum response of a simple structure, referred to as the spectral response quantity, may be used in the form of spectral acceleration, velocity or displacement. The use of a particular hazard parameter is specific to the infrastructure element being assessed. For example, damage to buildings is often related to the spectral displacement, whereas peak ground velocity is commonly used for pipelines.

Furthermore, fragility curves are generally organized in sets for a specific infrastructure component. HAZUS-MH MR2 requires four fragility curves per infrastructure item - one per damage limit state. Damage limit states included in HAZUS-MH MR2 are slight, moderate, extensive, and complete (Kircher et al, 1997). Many fragility relationships for types or classes of structures exist in the literature (a brief description is provided in Elnashai (2003)). In this report, the default fragility relationships of HAZUS-MH MR2 are employed. In future phases, uniform reliability fragility relationships based on advances simulations will be used (Nielson and DesRoches, 2004, 2006a, 2006b; Gencturk et al, 2007). For further information on fragility relationships, reference is made to Appendices III and IV.

Social Impacts

Social impacts include a wide variety of requirements associated with a population in a post-disaster environment. HAZUS-MH MR2 encompasses several estimates including displaced households (residences and families), short-term shelter population, and casualties. The number of displaced households is estimated based on the extent of damage to residential buildings along with building classification (single family, multi-family dwelling). In some cases, the number of displaced households may also include factors for the loss of utility services.

Estimates for the number of people seeking shelter are calculated as a percentage of the displaced population, taking into consideration demographic composition factors including ethnicity, age, and income level. These demographic factors influence the number of families seeking shelter in a region. For example, those families with limited financial means are more likely to seek public shelter and require short-term housing.

Additional social impact models include more detailed predictions for the displaced population. Food, refrigeration, sleeping and water requirements are determined as well

as space requirements for housing the shelter seeking population. Furthermore, the percentage of the displaced population requiring medical attention for chronic illnesses is estimated and can be included in response plans.

Casualty estimates are also a critical element of social impact assessments. HAZUS-MH MR2 classifies all injuries and fatalities as casualties when reporting a total number, though severity level estimates are also provided. Four levels of casualties are reported in HAZUS-MH MR2, ranging from minor injuries not requiring hospitalization to fatalities.

Examination of the outputs for both displaced populations and shelter seeking populations led to the conclusion that the calculations being performed within HAZUS-MH MR2 were incorrect due to errors in the software. This is currently being corrected in the next release of the software. To calculate these estimates for the scenarios discussed in this report, the project combined the damage estimates and population estimates from HAZUS-MH MR2 and utilized the HAZUS-MH MR2 methodology to derive the number of displaced people and the shelter seeking population. For further information on social impact methodology, please refer to Appendix III.

Consequence Assessment Software

In this phase of the project, use is made exclusively of HAZUS-MH MR2 (FEMA, 2007). Earlier work using other versions of HAZUS was repeated after careful comparisons with the newer version. HAZUS provides extensive libraries of models and data that can be used in a default mode. Most HAZUS models were retained whilst almost all HAZUS data was over-written by more comprehensive information. Significant changes were made to the social impact model in HAZUS, as elaborated upon in this report. In phase II of the project, which is currently underway, HAZUS analyses are augmented by specialized analysis using MAEviz release 3.0 (MAEviz, 2008). Special emphasis is paid in MAEviz to the utility and transportation network disruption, and the optimized allocation of temporary housing to the displaced population. The architecture and application of MAEviz are described in Elnashai et al (2008, a and b), while the temporary housing model features are presented in El-Anwar et al (2008).

Phase I Earthquake Hazard

The Central U.S. is not often thought of as a seismically active region, although the April, 2008 earthquake near Mt. Carmel, Illinois, brought a great deal of attention to this region and its potential seismic hazards. Though this particular event occurred on the Wabash Valley Fault in Southern Illinois, the larger and more active New Madrid Seismic Zone (NMSZ) is only a short distance away. Stretching from southwest Illinois to northeast Arkansas, the NMSZ is located in portions of five states in the Central U.S.: Illinois, Missouri, Kentucky, Tennessee and Arkansas.

This seismic region has produced some of the most major seismic events in U.S. history. During the winter of 1811 and 1812, a series of three earthquakes, with magnitudes of around 8, struck northeast Arkansas and southeast Missouri. These magnitudes were determined based on witness reports at the time of the events, liquefaction features dated to that period of time, and fault structure (Johnston & Schweig, 1996). At the time of these earthquakes, the Central U.S. was sparsely populated, with very few structures. Of the few buildings constructed in the region, many were likely for residential or agricultural use and of low quality. Currently, however, the Central U.S. is vastly populated with major population centers in Memphis, TN and St. Louis, MO. Both of these cities are likely to sustain damage from a NMSZ event, and particularly Memphis in particular could see severe damage.

According to Hildenbrand et al. (1996), the chance of a magnitude 6 or 7 earthquake occurring within the next 50 years is roughly 90%. Additionally, more than 3,000 earthquakes have occurred in the NMSZ since 1974 (Johnston & Schweig, 1996). An earthquake of magnitude 7, as has been predicted, or a recurrence of the 1811-1812 series could have devastating impacts on the region, with considerable national repercussions, as transportation routes, natural gas and oil transmission pipelines are broken and services are interrupted. Preliminary estimates, including those completed by the Mid-America Earthquake Center (MAEC), found that economic losses from a magnitude 7.7 (M_w7.7) event in the NMSZ could reach \$50-\$80 billion dollars in direct losses alone. Additionally, there could be thousands of fatalities, tens of thousands of injured victims, and even hundreds of thousands left without homes. The first step in developing earthquake impact assessments is developing scientifically defensible ground motion for a NMSZ M_w7.7 event upon which earthquake impact assessment models are based.

All ground motions employed in this study were developed by the U.S. Geological Survey. Three different events are considered, one for each presumed segment of the New Madrid Fault. Figure 1 illustrates the locations of each fault segment. The primary fault, shown in Figure 1, illustrates the three segments: northeast, central and southwest. The northeast and southwest segments are strike-slip faults while the central, or reelfoot segment, is a thrust fault. The presumed fault boundaries are not shown here, though they were used in the development of the national seismic hazard maps to account for the uncertainty of fault rupture (Frankel et al., 1996; Frankel et al., 2002). Figure 1 is similar to the single fault location shown in Johnston & Schweig (1996). The ground motion maps developed for the NMSZ are based on the rupture of a single segment, meaning the northeast, central and southwest segments are independent events which model the rupture of the entire fault segment length. Ground motion for each segment rupture is attenuated through rock and then propagated through the layer of soil on top of the bedrock layer. The specific procedure used to develop these three M_w7.7 deterministic events is similar to the method used for NMSZ probabilistic maps developed by the USGS. For further information on the method by which these maps were developed, please refer to Cramer (2006). Modeling in HAZUS-MH MR2 requires four ground shaking parameters to complete an earthquake impact assessment: peak ground acceleration (PGA), peak ground velocity (PGV), short-period spectral acceleration (S_a 0.3 sec.) and long-period spectral acceleration (S_a 1.0 sec.). Maps were developed for

each of these parameters. This means that each segment rupture requires a suite of four maps to fully define the ground motion for use in HAZUS-MH MR2.

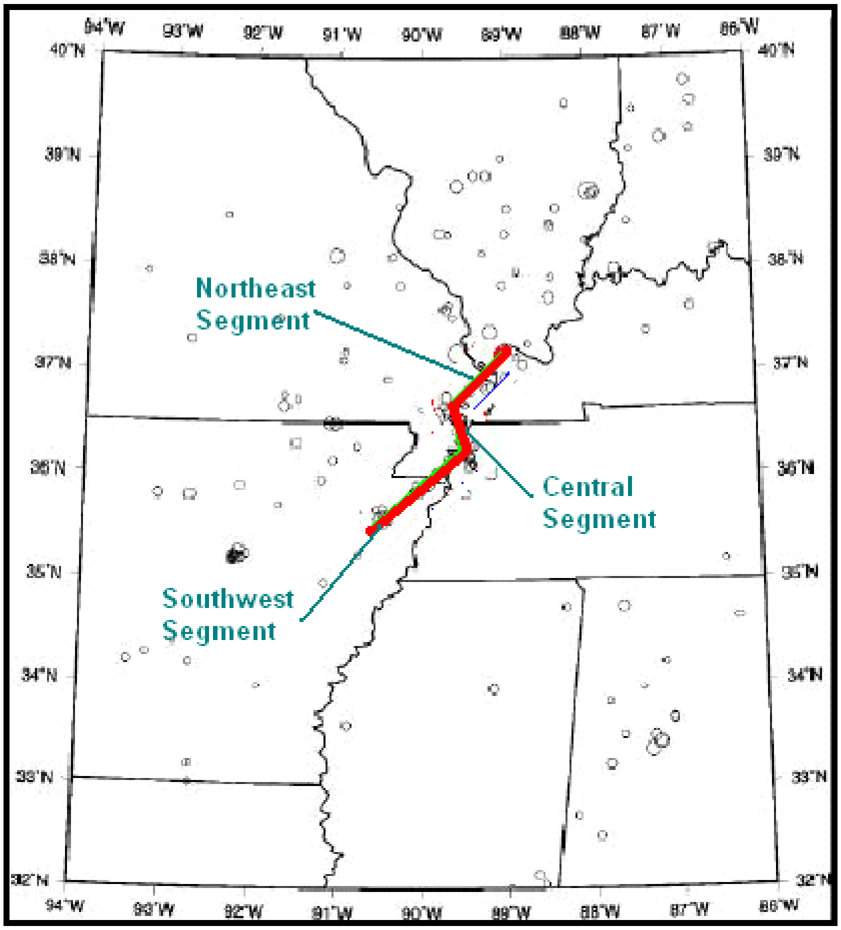

Figure 1: New Madrid Seismic Zone Fault Segments

Earthquake impact assessments are completed for each of the eight states in the NMSZ. The maps developed by Cramer and the USGS did not cover the full extent of the eight state region, so shaking values are specified for the four shaking parameters. Parameters are specified in outlying areas as follows:

- PGA = 0.05g
- PGV = 3 in./sec.
- S_a 0.3 sec. = 0.12g
- S_a 1.0 sec. = 0.11g

Original ground motion maps for PGA are shown in Figure 2 for the northeast segment, Figure 3 for the central segment, and Figure 4 for the southwest segment.

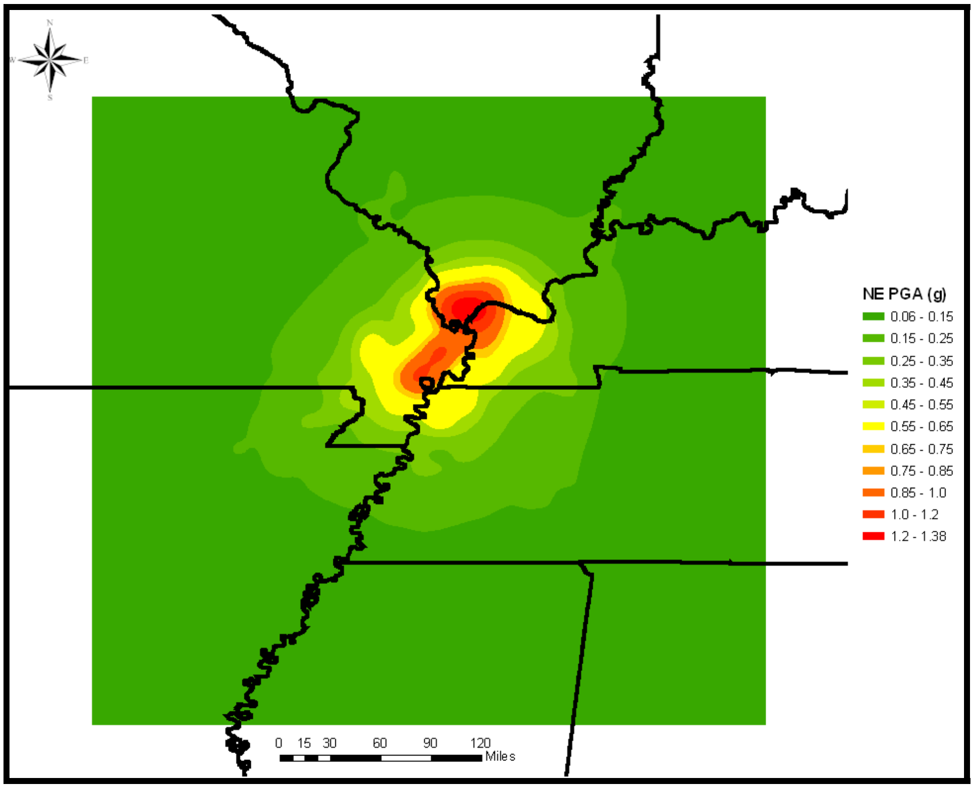

Figure 2: Northeast Segment of Middle Fault PGA (g)

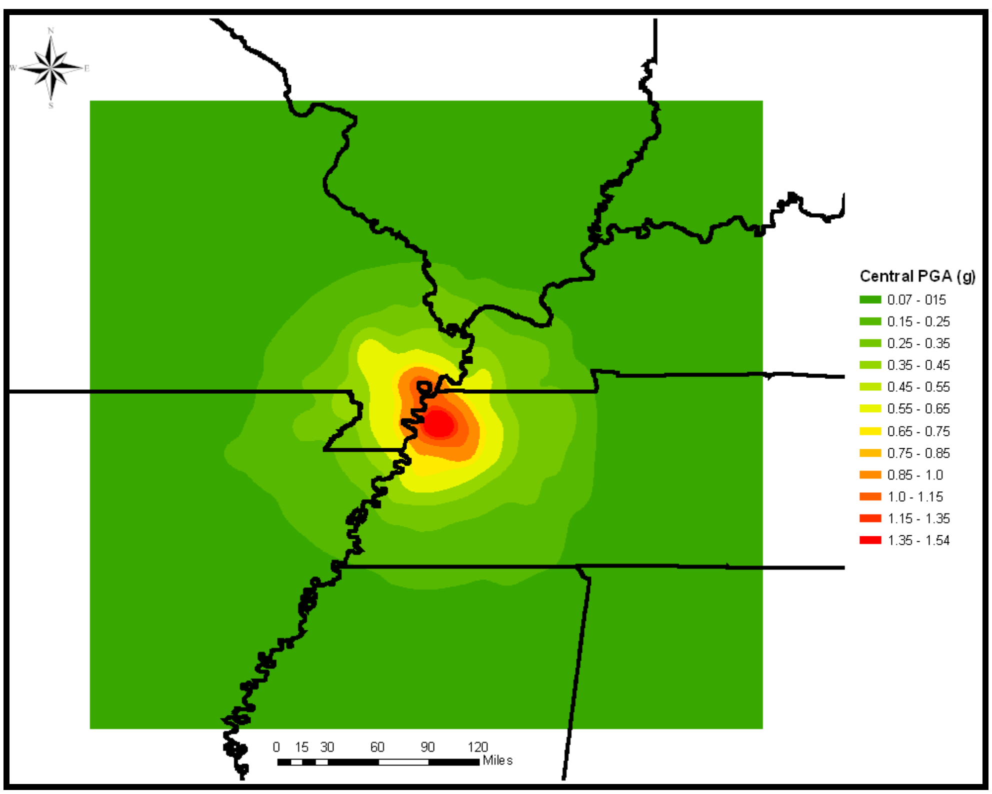

Figure 3: Central Segment of Middle Fault PGA (g)

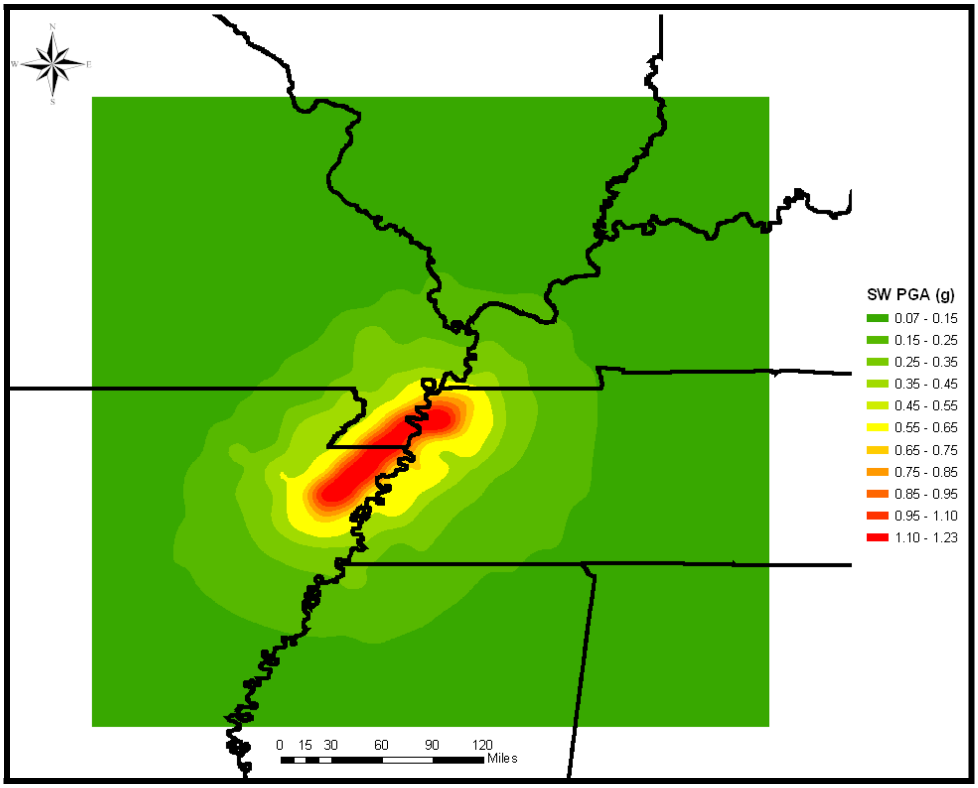

Figure 4: Southwest Segment of Middle Fault PGA (g)

Additionally, maps developed for the middle fault are shifted to the fault zone boundaries to determine the worst case event for all states except Arkansas. The MAEC was advised by the Arkansas State Geologic Survey to use the middle fault for the earthquake impact assessment in the State of Arkansas. As a result, each state's worst case event is described by a fault segment and shifting direction, such as east, west, or middle fault. The ground motion is shifted according to the follow descriptions for each state:

- Alabama: Southwest segment of eastern fault boundary line
- Arkansas: Southwest segment of middle fault line
- Illinois: Northeast segment of western fault boundary line
- Indiana: Northeast segment of eastern fault boundary line
- Kentucky: Northeast segment of the eastern fault boundary line
- Mississippi: Southwest segment of the eastern fault boundary line
- Missouri: Central segment of the western fault boundary line
- Tennessee: Southwest segment of the eastern fault boundary line

Two additional scenarios are considered for events outside the NMSZ. The first is a magnitude 7.1 (M_w7.1) earthquake in the Wabash Valley Seismic Zone (WVSZ) in Southern Illinois and Indiana. The ground motion maps for this event were also developed by the USGS and model the rupture of a length of fault. Figure 5 illustrates the location of the WVSZ and the Wabash Valley Fault. The PGA for the WVSZ event is illustrated in Figure 6. The procedure used to develop this map is similar to the method used to develop the NMSZ maps. Though a WVSZ event will impact the State of Illinois,

this scenario is only completed for the State of Indiana as the WVSZ produces greater damage than the NMSZ event.

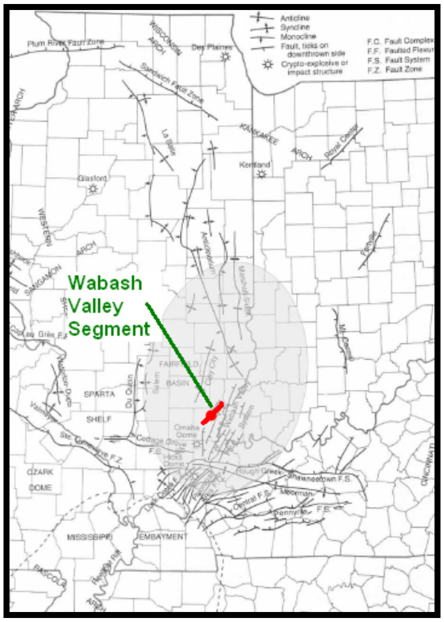

Figure 5: Wabash Valley Seismic Zone and Fault Location

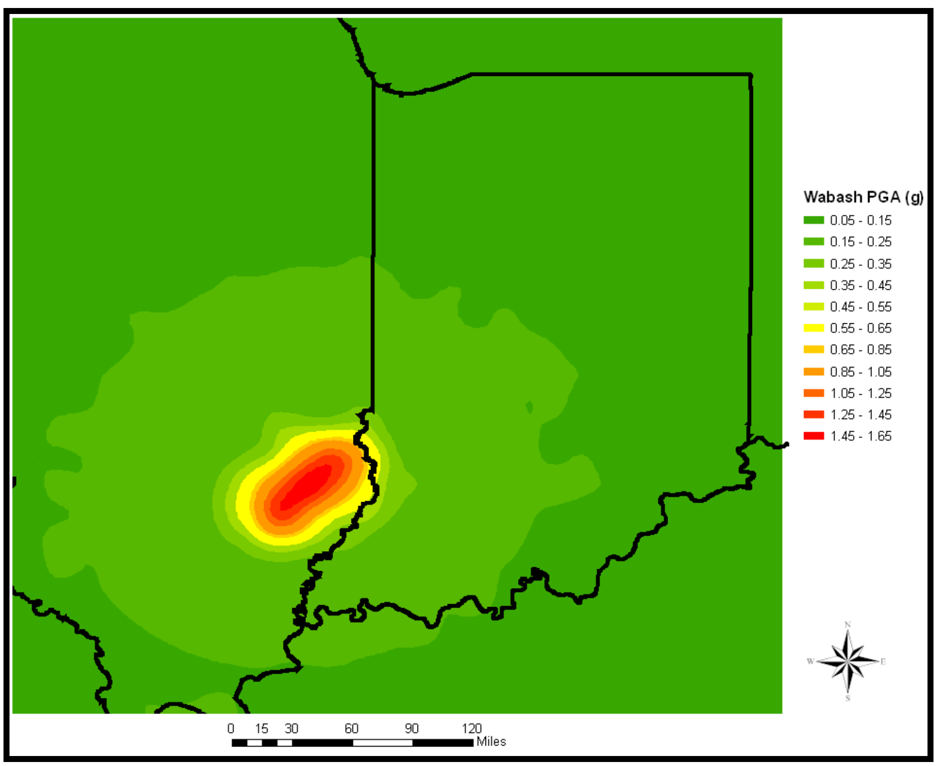

Figure 6: Wabash Valley Seismic Zone PGA

The final hazard scenario analyzed is a magnitude 5.9 (M_w5.9) event in the East Tennessee Seismic Zone (ETSZ). The Alabama Geologic Survey provided data to define this event, including the location of the epicenter and the depth. In contrast to the other scenarios, this ETSZ scenario ground motion is defined using a suite of attenuations. These attenuations, five in all, comprise the Central and Eastern U.S. (CEUS) Characteristic Event as specified in HAZUS-MH MR2. The attenuations employed are listed below with the weighting factor used:

Atkinson and Boore (1997)	0.250
Toro, Abrahamson and Schneider (1997)	0.250
Frankel, Mueller, Barnhard, Perkins et al. (1996)	0.250
Campbell (2002)	0.125
Sommerville, Collins, Abrahamson et al. (2002)	0.125

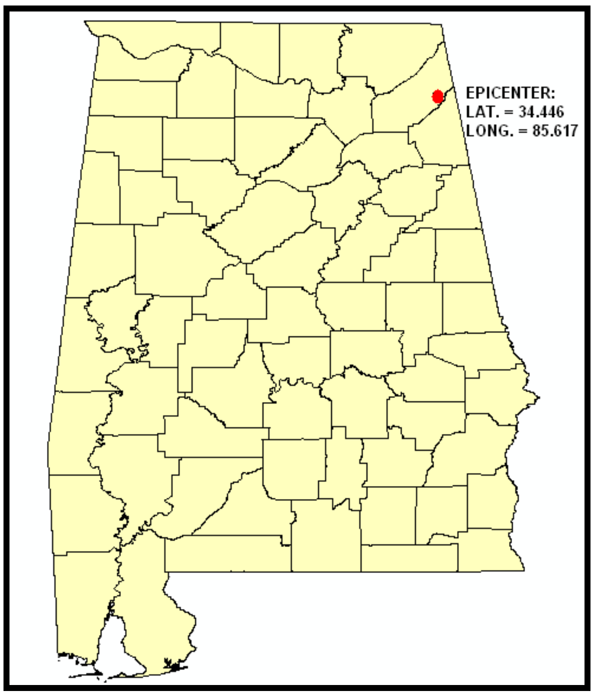

Figure 7: East Tennessee Seismic Zone Event, M5.9

The location of the ETSZ event is illustrated in Figure 7. The PGA that results from the suite of attenuations is illustrated in Figure 8. This event generates substantial ground motion in the northeastern portion of the state while the NMSZ event will generate the most intense shaking in the northwestern portion of the state. Comparing the hazard maps for the two scenario ground motions in Alabama, the ETSZ event generates significantly higher ground motion, particularly near the source. For additional information on all scenario ground motion maps including shifting parameters, please reference Appendix I.

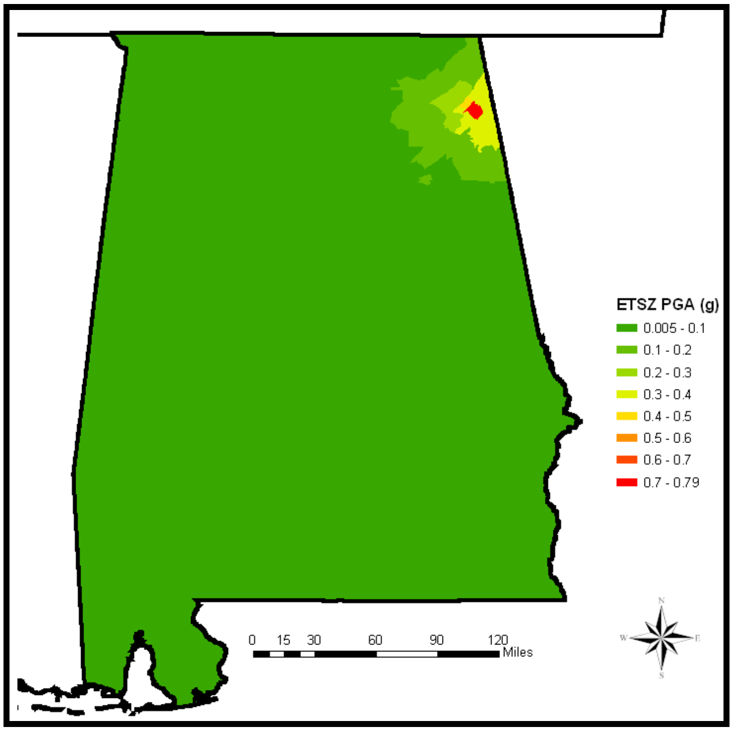

Figure 8: East Tennessee Seismic Zone PGA

In this series of analyses, hazard characterization is also improved by the addition of liquefaction susceptibility which captures the effects of permanent ground deformation. All NMSZ scenarios, and the WVSZ scenario, utilized a liquefaction susceptibility map that was developed via a proxy that correlates a soil site class (based on National Earthquake Hazard Reduction Program [NEHRP] specifications) to a relative level of liquefaction susceptibility. It should be known that this method is not the most accurate method; rather, it was the only data of this type available at the time these earthquake impact assessment scenarios were completed. The use of this form of liquefaction data will capture the regional effects of ground deformation, but should not be used for smaller-scale, site-specific studies. The correlation between soil site class and relative level of liquefaction susceptibility is detailed below in Table 1:

Table 1: Liquefaction Susceptibility Proxy

Soil Class	Description of Soil	Liquefaction Susceptibility Level
A	Hard Rock	NONE
B	Rock	NONE
C	Very Dense Soil & Soft Rock	NONE
D	Stiff Soils	LOW
E	Soil Soils	MODERATE
F	Soils Requiring Site-Specific Evaluation	VERY HIGH

The map of liquefaction susceptibility developed based on proxy information is illustrated in Figure 9. It is evident that a large portion of the region is not covered by the

liquefaction susceptibility map. Since no liquefaction susceptibility information is specified in these areas, permanent ground deformation is not included in the direct damage model, meaning damage determinations do not account for permanent ground deformations. Common liquefaction susceptibility levels are ‘very high,’ ‘moderate’ and ‘low.’ The ETSZ scenario was completed several months after the NMSZ and WVSZ scenarios, and by that time a new liquefaction susceptibility map was completed for the State of Alabama. This new map is employed in the earthquake impact assessment for the ETSZ scenario. Figure 10 illustrates the new liquefaction susceptibility map, which covers the entire State of Alabama.

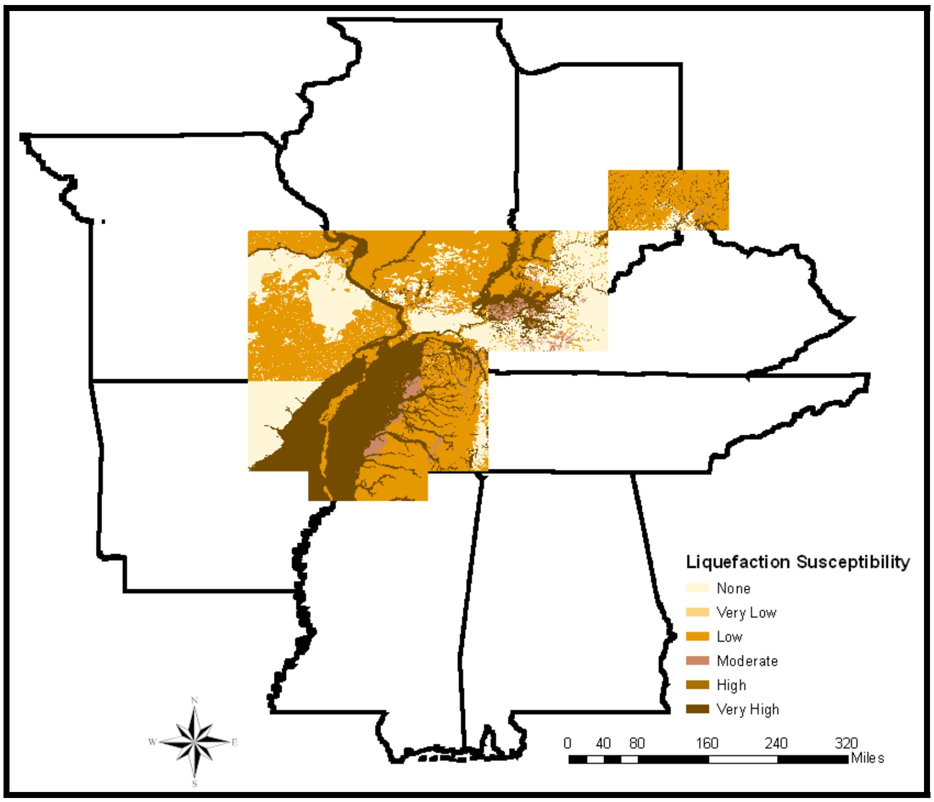

Figure 9: Liquefaction Susceptibility Map

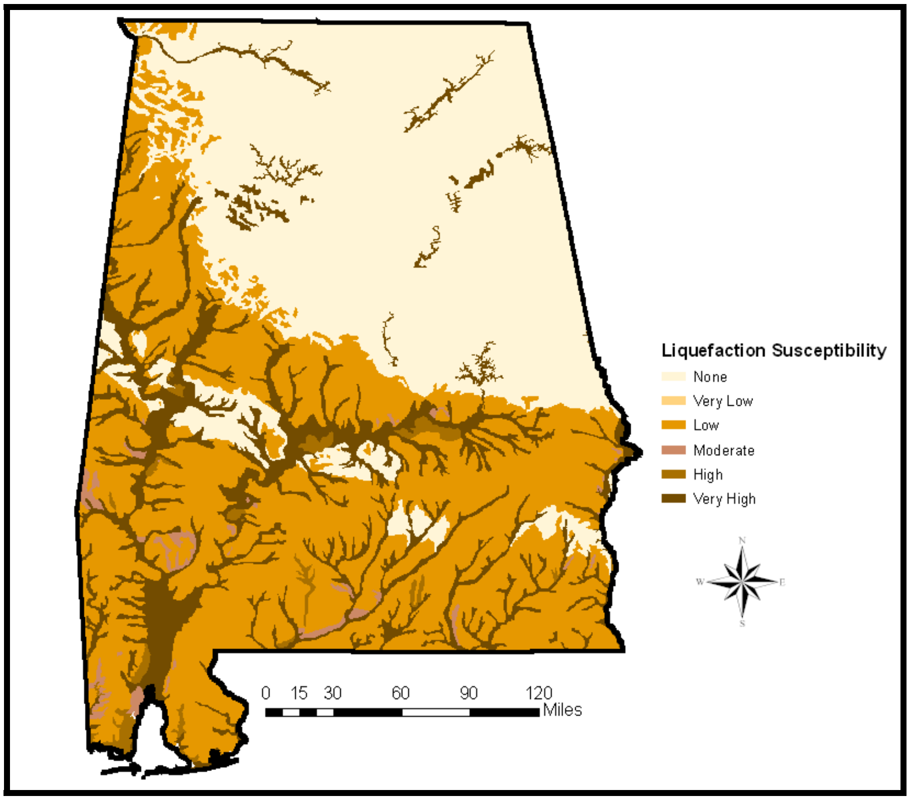

Figure 10: Liquefaction Susceptibility for ETSZ Scenario

The hazard in this region of the U.S. is a matter of vigorous debate, largely due to the lack of information from significant seismic events. The ground motion and liquefaction information utilized was the best available at the time these analyses were completed. Improvement of ground motion and liquefaction characterizations in the Central U.S. is an on-going effort and future phases of this project will include updated information. The changes made to the hazard in this investigation, however, are a substantial improvement over the default settings in HAZUS-MH MR2 and go a long way to representing the regional hazard.

Phase I Inventory

The inventory used in this series of earthquake impact assessments is classified into two major categories; population and infrastructure. The population is divided into various demographics which include age, gender, income level and numerous others. Income level is a critical factor when determining the number of people seeking public shelter in a post-disaster environment. The eight states included in this investigation have a total population of roughly 44 million people. Over 25% of the eight-state population resides in Illinois, with the City of Chicago alone contributing several million people. Tennessee and Missouri also contribute nearly six million residents each. Population totals for each state as of the year 2000 census are illustrated in Table 2. Additionally, population distributions of the eight states are shown in Figure 11 through Figure 18.

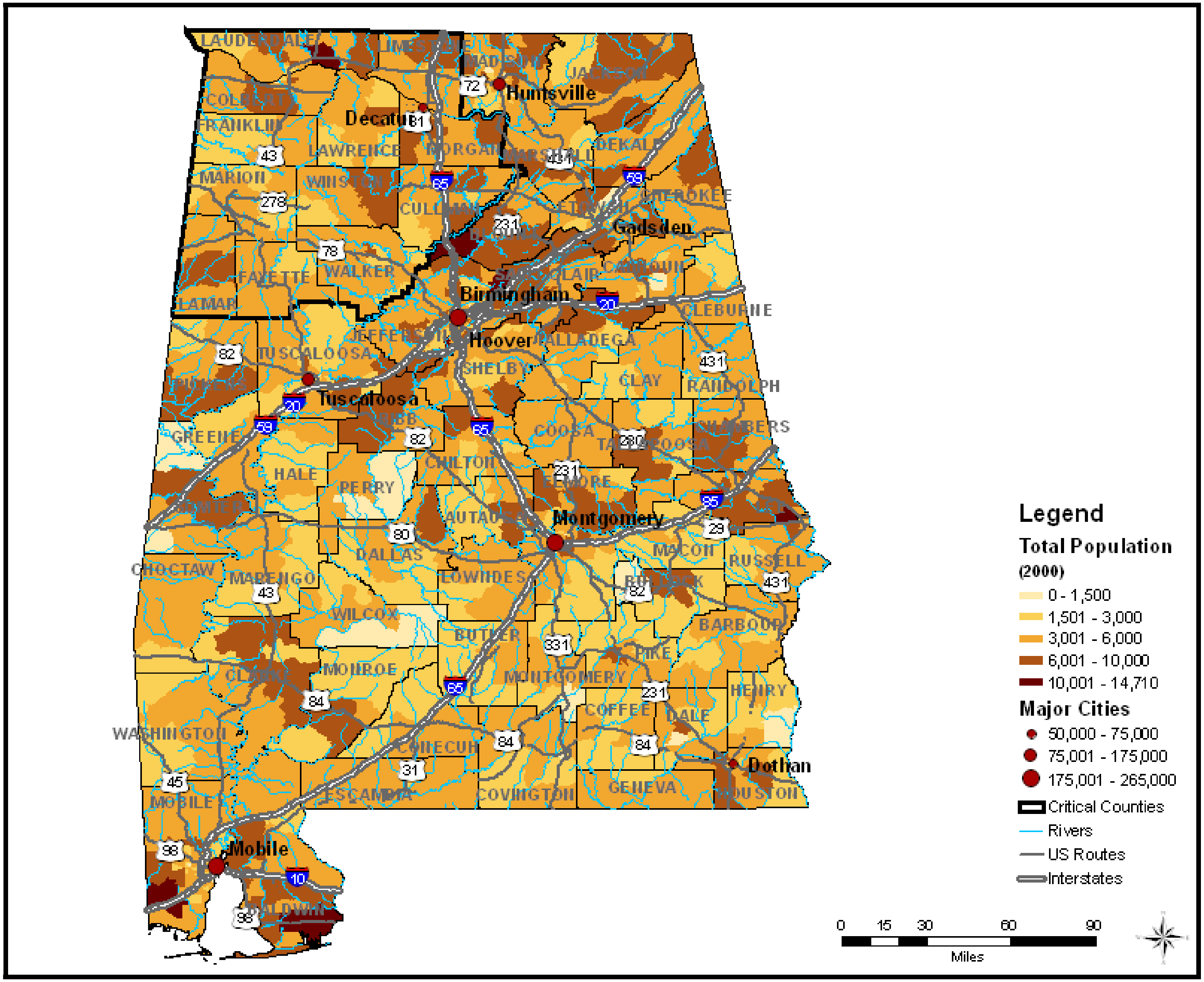

Figure 11: Population Distribution for the State of Alabama

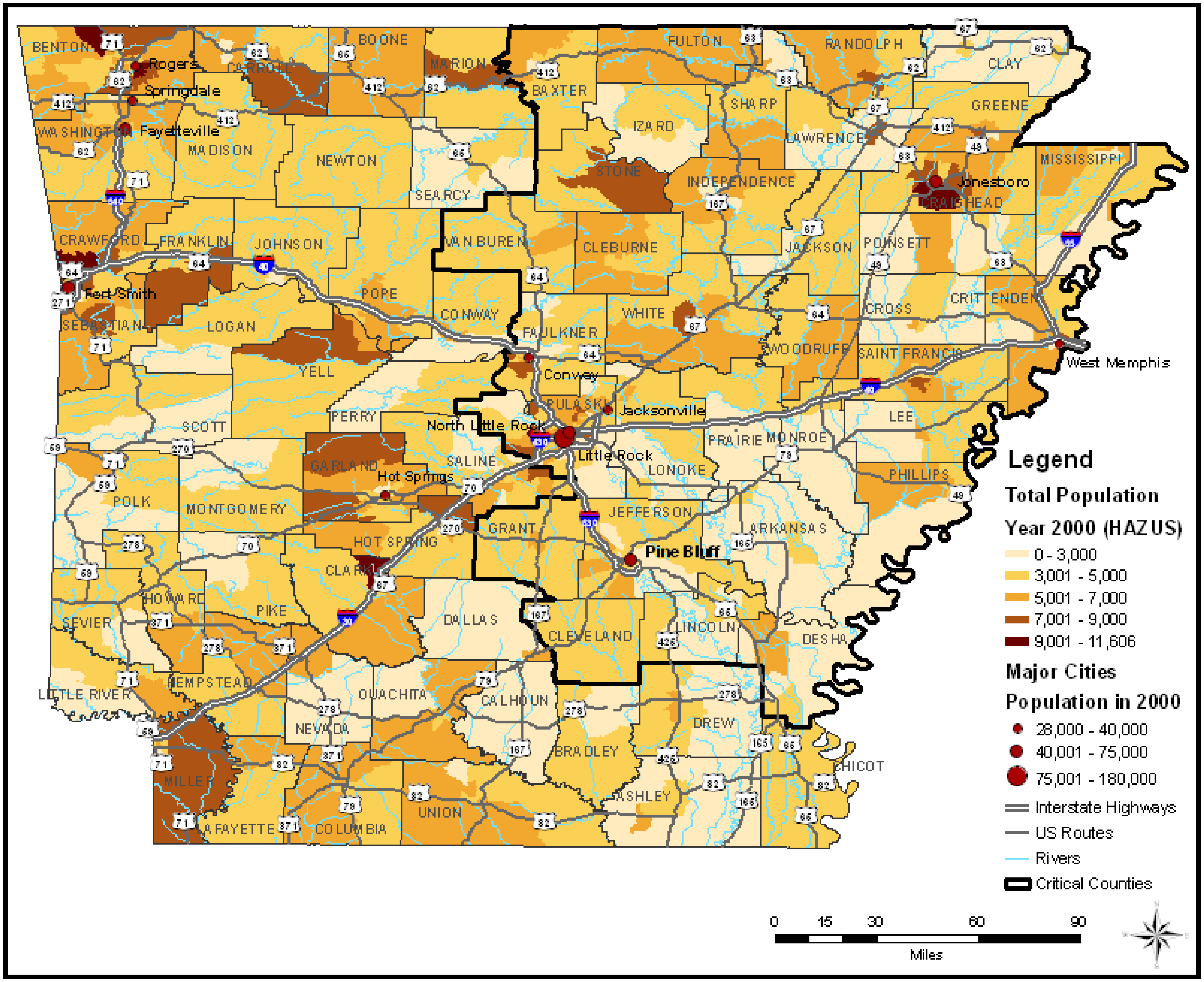

Figure 12: Population Distribution for the State of Arkansas

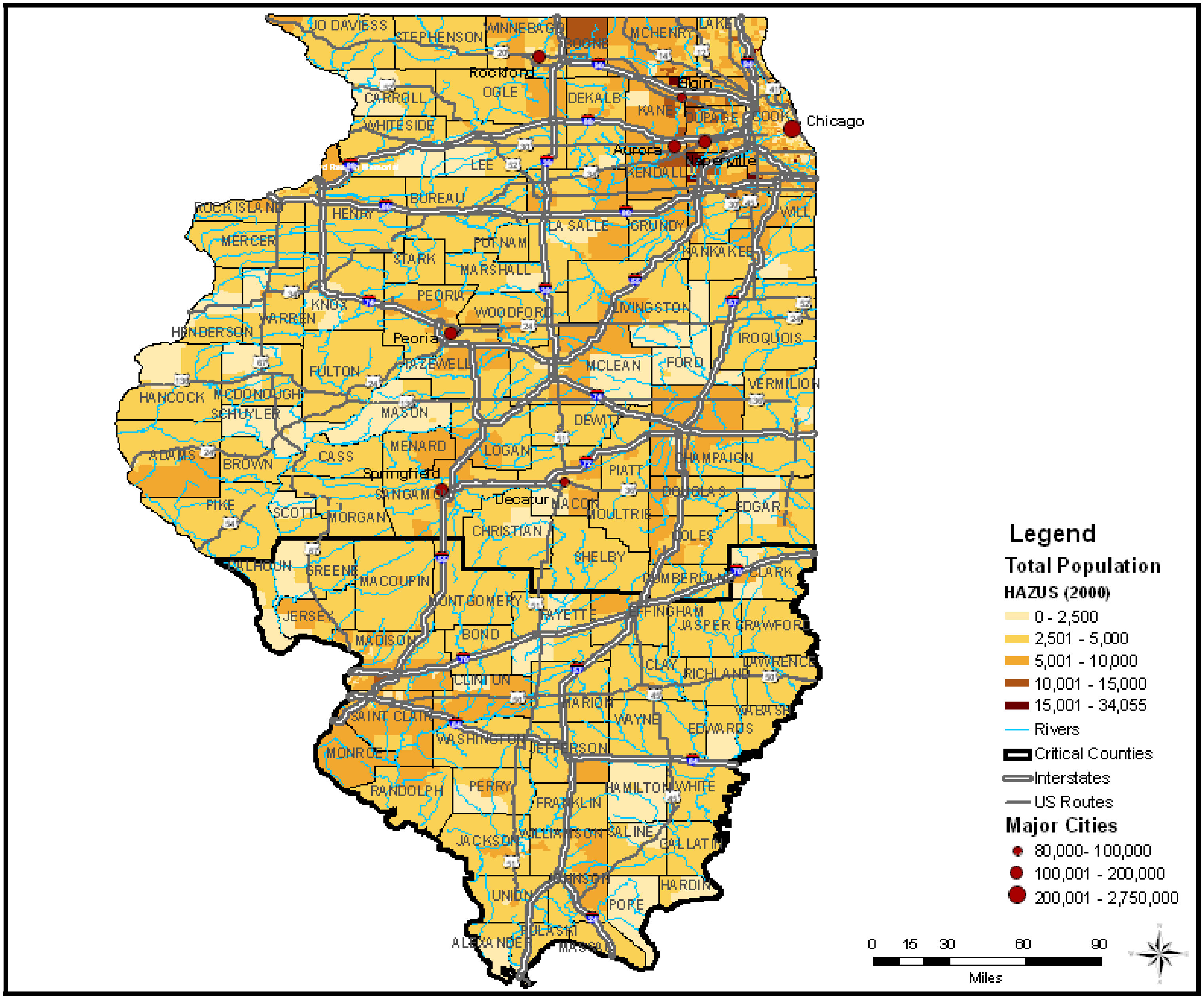

Figure 13: Population Distribution for the State of Illinois

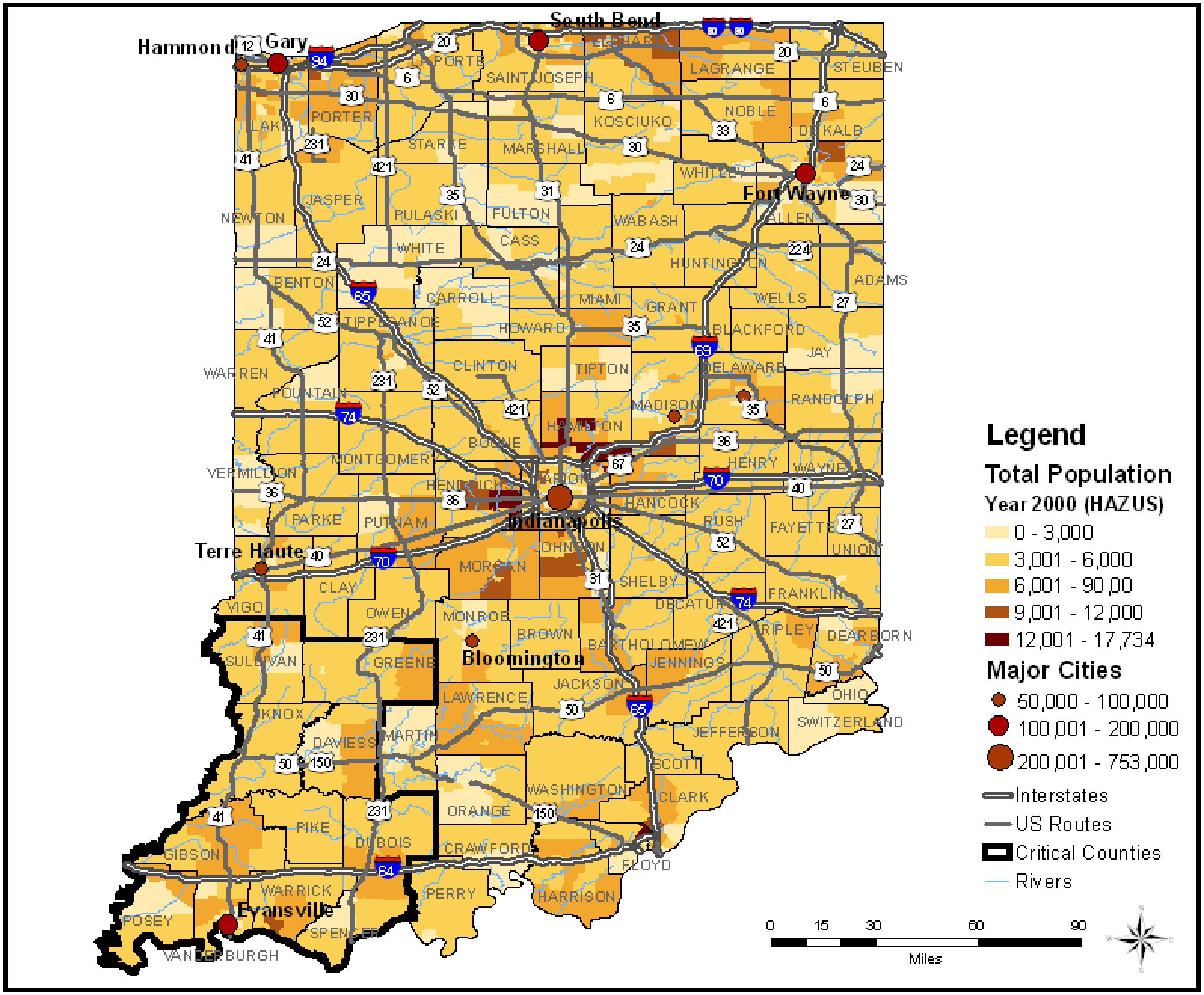

Figure 14: Population Distribution for the State of Indiana

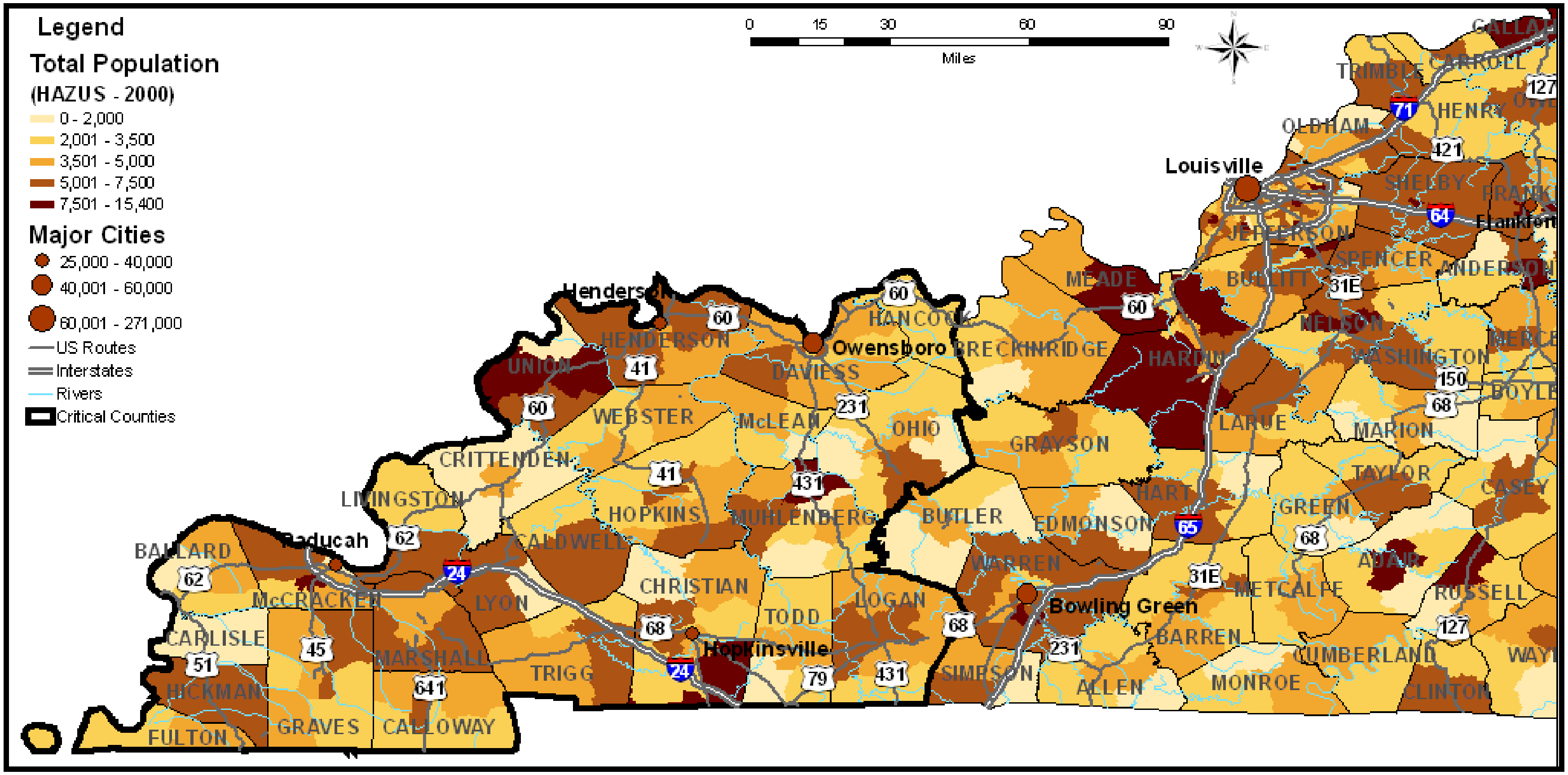

Figure 15: Population Distribution for the State of Kentucky

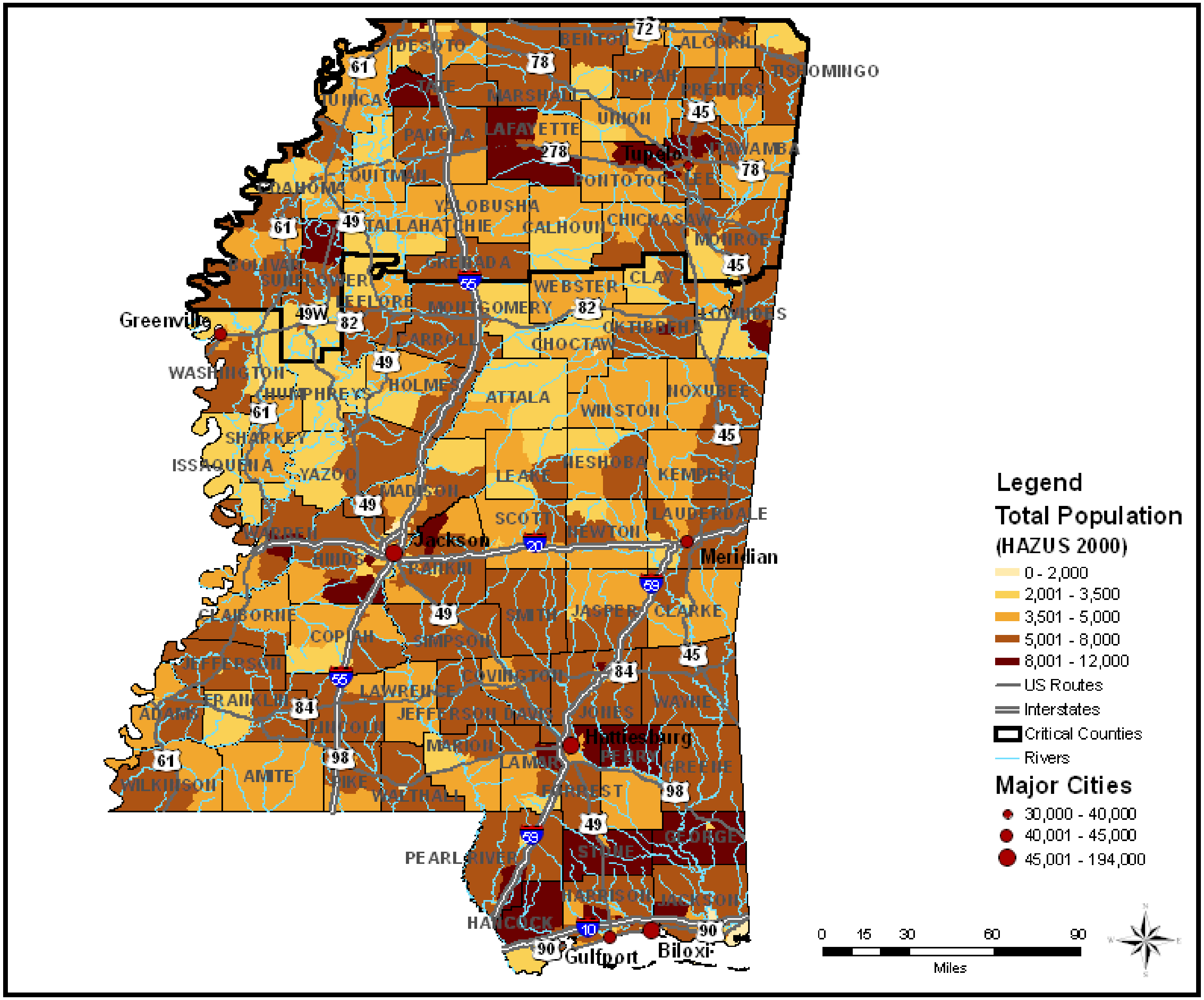

Figure 16: Population Distribution for the State of Mississippi

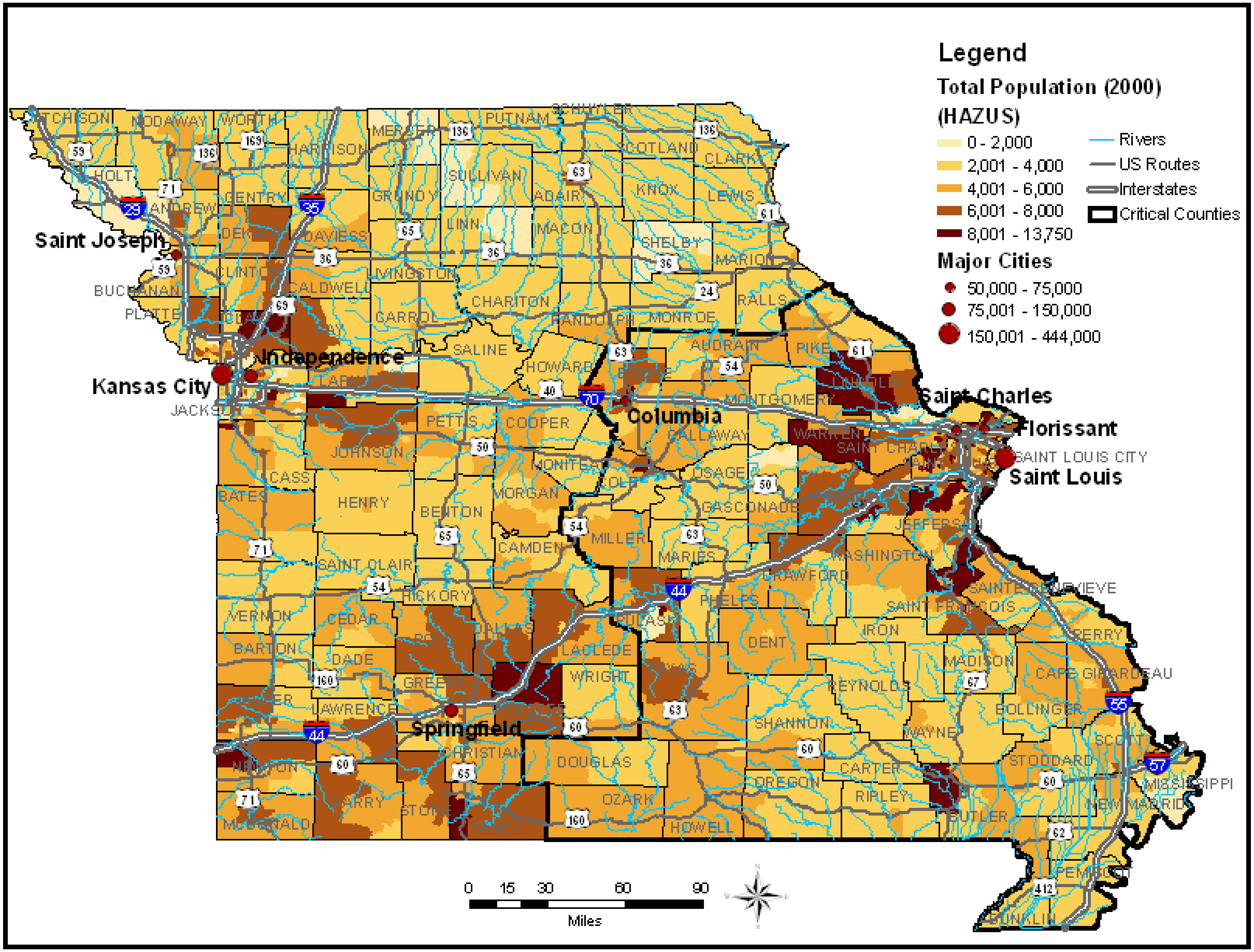

Figure 17: Population Distribution for the State of Missouri

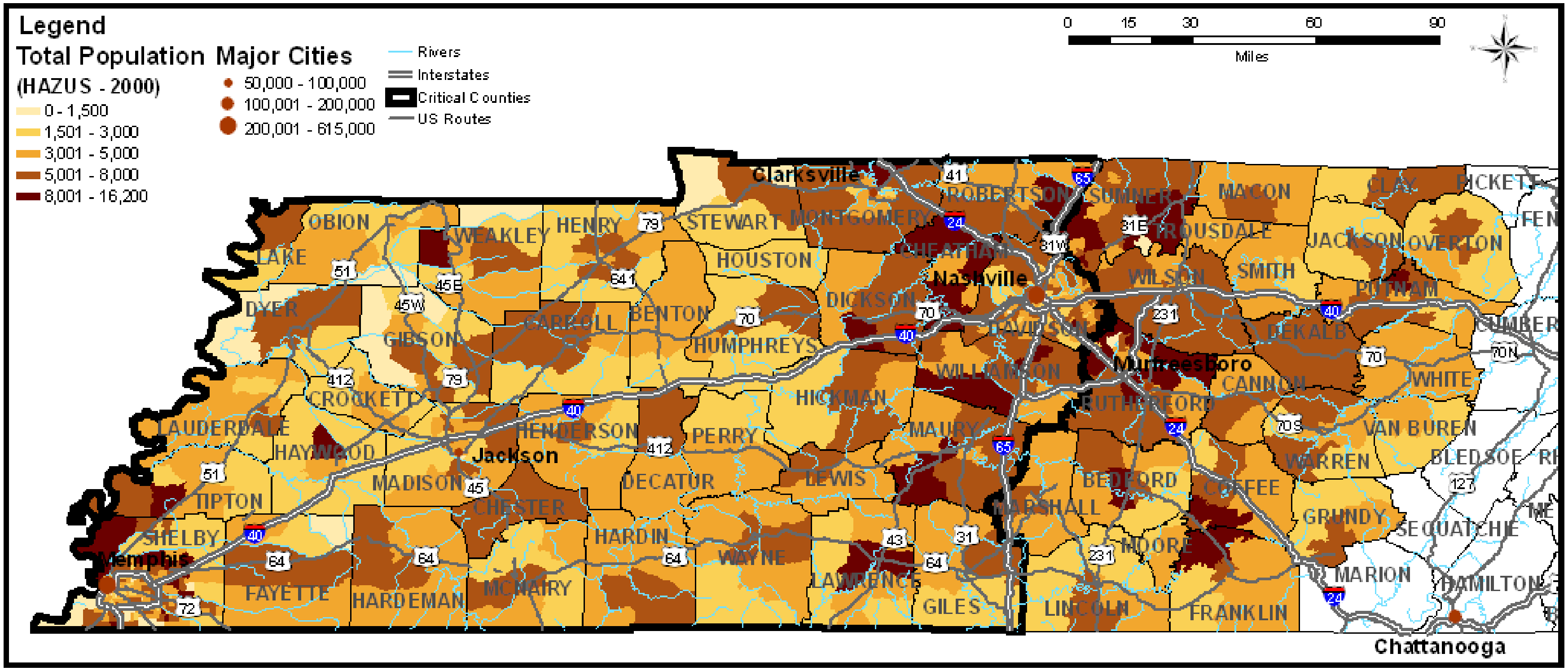

Figure 18: Population Distribution for the State of Tennessee

Table 2: Total Population of Eight-State Region (Year 2000 Census)

State	Population
Alabama	4,447,100
Arkansas	2,700,000
Illinois	12,400,000
Indiana	6,080,485
Kentucky	4,041,769
Mississippi	2,844,658
Missouri	5,595,211
Tennessee	5,689,283
TOTAL	43,798,506

All infrastructure and built environment is classified into three categories: buildings, transportation and utilities. The total value of all inventory, or assets, is quantified in Table 3. The entire eight-state region has a value of more than $6.7 trillion. The State of Illinois accounts for approximately 30% of that inventory value, while Kentucky and Missouri contribute roughly 15% each. Furthermore, utility lifelines represent nearly half of all inventory value in the eight states at nearly $3.2 trillion. Buildings account for $2.7 trillion and transportation lifelines contribute approximately $846 billion. This equates to 40% and 13%, respectively, of total inventory value.

Table 3: Inventory Value in Eight-State Region ($ millions)

State	Building Value	Transportation Value	Utility Value	Total Value
Alabama	$269,580	$108,231	$182,909	$559,720
Arkansas	$157,602	$67,940	$47,659	$273,201
Illinois	$837,682	$161,097	$1,001,676	$2,000,455
Indiana	$380,969	$107,793	$142,909	$631,671
Kentucky	$259,784	$128,036	$797,984	$1,185,804
Mississippi	$131,314	$69,176	$266,440	$466,930
Missouri	$334,877	$121,238	$564,861	$1,020,976
Tennessee	$329,827	$82,456	$173,425	$585,708
TOTAL	$2,701,635	$845,967	$3,177,863	**$6,724,465**

There are numerous subsets of inventory within the broad category of infrastructure. As shown in Table 3, the built environment can be broken down into the three major subcategories: buildings, transportation lifelines and utility lifelines. HAZUS-MH MR2 provides basic inventory data for all three of these subcategories, though improving upon this default data is highly recommended for a high-quality earthquake impact assessment. Due to the time required to update all inventory over the entire eight-state region, only select infrastructure categories are updated. Building inventory is one of the most time-consuming forms of data to update and as a result was not done in this investigation. The default building data is classified in two ways: by building/construction type and occupancy or building use type. There are 33 occupancy types, such as residential, commercial, industrial, government, educational, agricultural and religion. These are

considered general building types and within these general types are specific building types which can be found in Chapter 4 of the HAZUS-MH MR2 Technical Manual. There are 36 total building types which classify building by the type of structure and material used in construction. Such building types include wood frame, concrete, steel, precast concrete, unreinforced masonry, reinforced masonry and mobile homes. As with occupancy type, there are numerous specific building types which can also be found in Chapter 4 of the HAZUS-MH MR2 Technical Manual (FEMA-NIBS, 2006).

Transportation and utility lifelines are updated with information from the Homeland Security Infrastructure Program (HSIP) 2007 Gold Dataset (NGA Office of America, 2007) for critical infrastructure. In order to capture the most complete datasets possible HSIP and HAZUS-MH MR2 default data were combined and the duplicate inventory items removed. The infrastructure compone nts that are supplemented with HSIP data are listed below:

- Essential Facilities
    - Schools
    - Hospitals
    - Emergency Operation Centers (EOCs)
    - Police Stations
    - Fire Stations
- Transportation Lifelines
    - Highway Bridges
    - Railway Bridges
    - Airport Facilities
    - Ferry Facilities
    - Bus Facilities
    - Port Facilities
- Utility Lifelines
    - Natural Gas Facilities
    - Oil Facilities
    - Electric Power Facilities
    - Communication Facilities
    - Water Treatment Facilities (typically considered Waste Water Facilities)
    - Natural Gas Major Transmission Pipelines
    - Oil Major Transmission Pipelines
- High Potential-Loss Facilities
    - Hazardous Material Facilities
    - Dams
    - Levees
    - Prisons

Natural gas and oil major transmission pipelines are not part of the HAZUS-MH MR2 default inventory and are added as a new type of inventory. Adding these pipelines will not only supplement some local distribution networks already present in HAZUS-MH MR2, but will also provide information on the functionality of pipelines carrying critical

products to regions outside the NMSZ zone. For more information on the inventory used in this investigation please refer to Appendix II where infrastructure is quantified by state.

Phase I Fragility

The fragility curves provided in HAZUS-MH MR2 are intended for use throughout the USA. Using these provided—or default—fragilities for damage estimates means that building damage will not be determined for structural characteristics specific to the Central U.S., where the design and construction practice of all assets (e.g. bridges and buildings) are specific to the region. Additionally, in general, HAZUS-MH MR2 default fragilities are based on expert judgment and do not directly use observed or simulated structural responses. The published technical literature reports many different methods for the derivation of fragility relationships, based on observations, experimental testing, computer simulations, or combinations thereof. The advantage of using the HAZUS-MH MR2 default fragilities is that they provide relatively uniform and often conservative estimates of damage. They are therefore suitable for the regional assessment reported herein.

Building fragilities in HAZUS-MH MR2, for example, rely on the Capacity Spectrum Method (CSM) with empirical pushover curves to determine the capacity of the structure, while the demand is characterized by a single smoothed design spectrum. The general building inventory in HAZUS-MH MR2 is divided into 36 building types, each with a different set of fragility curves, which are further distinguished on the basis of found seismic design level (none, low, moderate and high).

Transportation and utility lifelines have individual sets of fragility curves which define their performance during a seismic event as well. HAZUS-MH MR2 employs 28 bridge types, for example, to categorize the performance of all bridges in a region's inventory. Many of these transportation (NIBS, 1999) and utility fragility curves (O'Rourke and Ayala, 1993) are based on expert opinion, due largely to the lack of research in these areas.

All HAZUS-MH MR2 default fragility curves are employed in the Phase I scenarios in this report. Updating fragilities will be undertaken in the next phase of the New Madrid Seismic Zone Catastrophic Planning project with a focus on buildings (Gencturk et al, 2007; Gencturk et al, 2008) and bridges (Nielson and DesRoches, 2004, 2006a, 2006b) using MAE Center derived fragility relationships that are specific to the Central USA.

Results of the Earthquake Impact Assessments

This section focuses on direct damage to infrastructure in the eight-state region around the NMSZ. Specifically, damage to buildings as well as damage and functionality of critical infrastructure (essential facilities, transportation and utility lifelines) are highlighted and presented by scenario. As mentioned earlier, there are ten total scenarios

completed in this phase of the NMSZ earthquake impact assessment project and brief discussions of impact assessment results are given here. At the conclusion of this section, general regional damage trends are identified and comparisons made with other published scenarios for a NMSZ event. In addition, each scenario identifies a set of counties that are expected to incur the greatest amount of damage. These counties are taken from a study completed at FEMA Region VIII. For more detailed explanations of results from each scenario, please refer to Appendix V.

State-Level Direct Damage & Functionality

Alabama New Madrid Seismic Zone Scenario

Each scenario completed in this investigation focuses on the critical counties, which are identified as counties in each state where shaking is most intense. Though shaking is less intense in Alabama than most other states, there are 12 counties identified in northwest Alabama that are expected to experience the majority of the damage in the state. These counties are illustrated in Figure 11 and are listed below:

- Colbert
- Cullman
- Fayette
- Franklin
- Lamar
- Lauderdale
- Lawrence
- Limestone
- Marion
- Morgan
- Walker
- Winston

The NMSZ M_w7.7 scenario for the State of Alabama generates the greatest amount of damage when the earthquake occurs in the southwest extension of the eastern fault. Building damage resulting from this event is detailed in Table 4 and Table 5. There are nearly 1.7 million buildings in the State of Alabama, most of which are not impacted by the NMSZ earthquake.

“Moderate” damage is much more common at the low levels of shaking experienced across the majority of the state. Residential buildings, which include single family homes and other residential structures, incur nearly 98% of all building damage in Alabama. Commercial structures experience over 100 cases of moderate damage, though that pales in comparison with the number of residential structures damaged. Though the distribution of damage in the critical counties is not shown here, only 2,900 cases of damage occur in the critical counties. This is less than 50% of all building damage, indicating that a large portion of damage occurs in the north-central portion of Alabama.

Damage to buildings is further classified by building type. The majority of moderate and extensive damage cases are incurred by mobile homes and unreinforced masonry buildings. Mobile homes and unreinforced masonry buildings are vulnerable to the moderate and low level of shaking (< 0.25g) in northern Alabama, hence the large percentage of damage cases occurring there. Two-thirds of the extensive damage and over 85% of moderate damage is experienced by mobile homes alone. Despite the large

proportion of damage incurred by mobile homes and unreinforced masonry buildings only 0.4% of Alabama buildings experience moderate and extensive damage, indicating that most of Alabama is undamaged by the earthquake.

Table 4: NMSZ Event Building Damage by Occupancy Type for State of Alabama

General Occupancy Type Damage			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	1,303,224	539	0
Other Residential	354,031	5,581	0
Commercial	18,249	119	0
Industrial	2,048	20	0
Other	2,014	9	0
Total	1,679,566	6,268	0

Table 5: NMSZ Event Damage by Building Type for State of Alabama

Building Damage by Building Type					
Building Type	None	Slight	Moderate	Extensive	Complete
Wood	1,258,071	6,679	120	0	0
Steel	11,399	439	97	3	0
Concrete	3,156	100	23	0	0
Precast	857	28	10	1	0
Reinforced Masonry	5,178	70	24	1	0
Unreinforced Masonry	74,050	3,436	506	18	0
Mobile Home	278,809	31,026	5,417	48	0
Total	1,631,520	41,778	6,197	71	0

Table 6: Essential Facilities Damage and Functionality for NMSZ Event in the State of Alabama[3]

Essential Facilities Damage & Functionality					
Essential Facility Type	Total No. Facilities (State)	Total No. Facilities (12 Critical Counties)	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
Hospitals	137	19	0	0	137
Schools	1,870	270	0	0	1,870
EOCs	27	3	0	0	27
Police Stations	496	78	0	0	496
Fire Stations	1,388	250	0	0	1,388

[3] For Tables in this section the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged.' Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged.'

There are thousands of essential facilities in the State of Alabama and over 500 in the 12 critical counties alone. Table 6 highlights the damage and functionality of those facilities. Due to the low level of shaking and lack of liquefaction information employed in the NMSZ run for Alabama, no damage and loss of functionality is estimated, even in the critical counties. Continued functionality of all essential facilities will be critical as Alabama is likely to provide support for other states with more severe impacts from a NMSZ event.

Highway bridges are very similar to essential facilities in that moderate or more severe damage is unlikely and the loss of functionality is minimal. All other transportation lifelines are similar as well, with all facilities operational the day after the earthquake. This will permit emergency vehicles and aircraft to access the State of Alabama easily, where many displaced people may be housed.

Table 7: NMSZ Event Damage to Highway Bridges in the State of Alabama[4]

Highway Bridge Damage Assessments				
	Total No. of Bridges	**At Least Moderate Damage (Damage > 50%)**	**Complete Damage (Damage > 50%)**	**Functionality >50% at Day 1**
12 Critical Counties	2,366	0	0	2,366
Remaining Counties	12,231	0	0	12,231
Total State	14,597	0	0	14,597

Table 8: NMSZ Event Damage to Pipelines in the State of Alabama

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water – Local	200,893	722	180
Waste Water – Local	120,536	571	143
Natural Gas – Regional	8,558	3	1
Natural Gas – Local	50,705	610	152
Oil – Regional	2,913	1	0

Damage to all utility facilities is similar to damage estimates shown for transportation and essential facilities, and is not shown here. All utility facilities are expected to remain functional in the immediate aftermath of the earthquake. Furthermore, no facilities are anticipated to incur moderate or more severe damage. Minor damage may occur in the critical counties, though occurrences would be infrequent. Pipeline damage in local distribution networks is likely, however. Table 8 illustrates the level of damage predicted for local and regional pipeline networks in the State of Alabama. Regional natural gas and oil pipelines are not expected to incur much damage with minimal breaks and leaks, as shown in Table 8. This is critical because these are major transmission lines that carry critical supplies to the east coast and northeast U.S. Local networks incur substantially more damage with several hundred leaks and breaks throughout the state. Despite the cases of damage to local pipeline networks, potable water service is expected to be

[4] See footnote (3).

retained for all residences the day after the scenario earthquake. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program. Though the number of leaks and breaks may appear to be large, they are spread across many miles of pipeline, resulting in no interruptions in service. For additional information on NMSZ Event damage in Alabama please refer to Appendix V.

Alabama East Tennessee Seismic Zone Scenario

The scenario for the East Tennessee Seismic Zone is located in northeastern Alabama and thus a new set of critical counties is required. There are 13 counties that experience the most intense shaking from the ETSZ event and though they are not highlighted in Figure 11, they are visible in the northeast corner of the state. These 13 critical counties are as follows:

- Blount
- Calhoun
- Cherokee
- Dekalb
- Etowah
- Jackson
- Jefferson
- Limestone
- Madison
- Marshall
- Morgan
- Saint Clair
- Talladega

Table 9: ETSZ Event Building Damage by Occupancy Type for the State of Alabama

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**At Least Moderate Damage**	**Complete Damage**
Single Family	1,303,224	2,431	410
Other Residential	354,031	3,241	127
Commercial	18,249	61	5
Industrial	2,048	48	2
Other	2,014	5	0
Total	1,679,566	5,786	544

The ETSZ event generates several thousand damaged structures, most of which occur in the 13 critical counties. Of the 544 "completely" damaged structures, all buildings are in the critical counties. Furthermore, all but 30 of the "at least moderately" damaged buildings are in the critical counties. Residential structures incur most of damage, with 98% of residential structures incurring at least moderate damage. Table 9 illustrates the distribution of damage by occupancy type for the ETSZ scenario event.

The higher peak ground accelerations in northeast Alabama produce several thousand cases of damage to wood frame buildings, in addition to the damage incurred by unreinforced masonry buildings and mobile homes. The addition of new liquefaction information to this scenario for Alabama is a major factor contributing to the number of complete damage cases. Over 70% of all complete damage cases occur in wood frame

buildings with another 20% coming from mobile homes. Additional information on building type damage is shown in Table 10.

The ESTZ event produces numerous cases of damage to critical facilities. Several fire stations, all near the epicenter in northeast Alabama, incur moderate or more severe damage. A total of 22 fire stations in that same region are not operational immediately after the earthquake and will inhibit the ability of those firefighters to respond to emergency calls. The same is true for non-operational police stations in northeast Alabama. Table 11 illustrates the damage and functionality loss expected for the ETSZ event in Alabama. Transportation lifeline damage to bridges is representative of all transportation infrastructure. Cases of damage and functionality loss are limited and located within miles of the epicenter. Table 12 highlights the damage and functionality estimates for the ETSZ event.

Table 10: ETSZ Event Building Damage by Building Type for the State of Alabama

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,255,446	7,365	1,596	69	392
Steel	11,814	64	42	14	4
Concrete	3,247	16	11	4	2
Precast	879	8	5	2	0
Reinforced Masonry	5,234	19	14	5	3
Unreinforced Masonry	76,394	1,127	371	81	38
Mobile Home	305,185	6,983	2,676	352	105
Total	1,658,199	15,582	4,715	527	544

Table 11: ETSZ Event Essential Facilities Damage for the State of Alabama[5]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	137	1	0	136
Schools	1,870	8	0	1,856
EOCs	27	0	0	27
Police Stations	496	6	0	485
Fire Stations	1,388	12	0	1,366

[5] See footnote (3).

Table 12: ETSZ Event Highway Bridge Damage for the State of Alabama[6]

Highway Bridge Damage Assessments				
	Total No. of Bridges	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality > 50% at Day 1**
13 Critical Counties	4,014	1	0	4,013
Remaining Counties	10,583	0	0	10,583
Total State	14,597	1	0	14,596

There are over 15,000 communication facilities in the State of Alabama and over 160 of those are expected to incur at least moderate damage from the ETSZ event (see Table 13). All damage is confined to the critical counties in northeast Alabama. Though no other utility facilities damage estimates are shown, other facility types follow the same distribution trends as communication facilities. For more detailed results on utility damage and functionality, please refer to Appendix V. Damage and functionality maps can be found in Appendix VIII.

Table 13: ETSZ Event Communication Facilities Damage for the State of Alabama[7]

Communication Damage Assessments			
	Total No. Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**
13 Critical Counties	5,180	162	0
Remaining Counties	10,161	0	0
Total State	15,341	162	0

Damage to pipelines is limited, with less than 500 total leaks and 200 total breaks throughout the state. All leaks and breaks occur along local distribution lines, which indicates that all major transmission lines remain intact and will continue transporting product in the days immediately after the earthquake. Service interruptions are shown in Table 14 for electric power facilities only, since no service interruptions are expected for potable water facilities. The day after the earthquake nearly 7,400 households are without power, with over 1,700 households still without power after one week. These service outages will prevent residents from remaining in their homes, resulting in some seeking temporary public shelter.

Table 14: ETSZ Event Service Interruptions for the State of Alabama

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Electric Power	1,737,080	7,389	4,367	1,715	349	10

[6] See footnote (3).
[7] See footnote (3).

Arkansas New Madrid Seismic Zone Scenario

The NMSZ event generates substantial shaking in northeastern Arkansas counties. There are 34 critical counties identified in this portion of the state that are expected to incur the majority of all damage. These critical counties are illustrated in Figure 12 and are also listed below:

- Arkansas
- Baxter
- Clay
- Cleburne
- Cleveland
- Craighead
- Crittenden
- Cross
- Desha
- Faulkner
- Fulton
- Grant
- Greene
- Independence
- Izard
- Jackson
- Jefferson
- Lawrence
- Lee
- Lincoln
- Lonoke
- Mississippi
- Monroe
- Phillips
- Poinsett
- Prairie
- Pulaski
- Randolph
- St. Francis
- Sharp
- Stone
- Van Buren
- White
- Woodruff

Buildings in Arkansas are heavily damaged by the NMSZ M_w7.7 event. Complete damage cases total over 50,000 while moderate and severe damage levels contribute another 61,500 cases. Table 15 quantifies damage estimates for various occupancy types. Of the over 1.2 million buildings in the State of Arkansas, more than 95% are residential buildings. Over 98% of all complete damage occurs in residential buildings, and the same is true of moderate and severe damage. All cases of complete damage occur in the 34 critical counties and approximately 59,700, or 97%, of moderate and severe damage occurs in the critical counties.

Wood frame buildings are a substantial portion of Arkansas' buildings and as a result many of these structures are damaged, as shown in Table 16. The significant shaking and highlight liquefiable soils in the critical counties are major factors contributing to the tens of thousands of cases of complete damage to wood frame buildings. While over 55% of all complete damage occurs to wood frame structures, unreinforced masonry structures and mobile homes account for 19% and 24% of all complete damage, respectively. All other buildings types comprise a much smaller portion of the building inventory and represent very small percentages of damaged structures.

Table 15: NMSZ Event Building Damage by Occupancy Type for the State of Arkansas

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	936,609	38,644	35,742
Other Residential	195,818	21,792	13,626
Commercial	8,078	796	555
Industrial	1,461	155	174
Other	1,169	102	62
Total	1,143,135	61,489	50,159

Table 16: NMSZ Event Building Damage by Building Type for the State of Arkansas

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	718,424	58,893	22,688	6,744	28,425
Steel	2,398	295	218	152	332
Concrete	776	92	58	47	81
Precast	820	97	89	53	100
Reinforced Masonry	444	35	33	28	65
Unreinforced Masonry	96,398	13,474	7,340	4,011	9,334
Mobile Home	115,965	23,376	12,704	7,324	11,822
Total	935,225	96,262	43,130	18,359	50,159

Essential facilities in the State of Arkansas are also substantially damaged by the NMSZ event. Over 150 of the 1,330 fire stations in Arkansas are at least moderately damaged with 191 not operational the day after the earthquake. In addition, 94 schools are damaged with 117 not functioning immediately after the event, as shown in Table 17. The combination of non-operational fire and police services in the critical counties will severely inhibit the ability of emergency workers to respond to requests for assistance. Hospitals in the critical counties are also out of service. Forty of the 103 hospitals in Arkansas are not operational the day after the earthquake, meaning nearly all hospitals in the critical counties will not be able to care for those injured by the earthquake or maintain care for current patients. Counties in western Arkansas will likely need to provide support for those out-of-service facilities immediately after the earthquake.

Table 17: NMSZ Event Essential Facilities Damage for the State of Arkansas[8]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	103	18	10	63
Schools	1,254	188	106	995
EOCs	11	1	1	10
Police Stations	515	94	43	398
Fire Stations	1,330	151	63	1,139

Transportation lifelines provide much-needed access to portions of the state that are severely damaged by the earthquake and damaged roads or airport runways will limit the assistance to these areas in the critical days after the event. Nearly 700 bridges, all in the critical counties, are damaged and not functioning (see Table 18) which limits the number of response workers, supplies and medical aid accessing northeast Arkansas. Though not shown here, several railway facilities, port facilities and airports are heavily damaged, further inhibiting the movement of people and supplies both into and out of the hardest hit areas. For more information on damage to the transportation infrastructure in Arkansas, please refer to Appendix V.

8 See footnote (3).

Table 18: NMSZ Event Highway Bridge Damage for the State of Arkansas[9]

Highway Bridge Damage Assessments				
	Total No. Of Bridges	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
34 Critical Counties	2,883	688	290	2,197
Remaining Counties	2,751	0	0	2,751
Total State	5,634	688	290	4,948

The damage to electric power facilities shown in Table 19 is representative of all utility facility damage in the State of Arkansas. Of the 29 electric power facilities in the critical counties eight are at least moderately damaged with one being completely damaged. Furthermore, eleven facilities are not operational the day after the earthquake, which greatly reduces the number of customers receiving services. Additionally, 66 waste water and 59 communication facilities are at least moderately damaged in the critical counties. Nearly half of the 229 waste water facilities in the critical counties are not operational the day after the earthquake.

Table 19: NMSZ Event Electric Power Facility Damage for the State of Arkansas[10]

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
34 Critical Counties	29	8	1	18
Remaining Counties	27	0	0	27
Total State	56	8	1	45

Table 20: NMSZ Event Utility Service Interruptions for the State of Arkansas

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	1,042,696	175,565	174,382	171,216	132,672	79,737
Electric Power		95,309	68,561	39,398	13,541	112

With extensive damage and functionality loss to critical utility facilities in the 34 critical counties, it then follows that utility service outages will be extensive. Table 20 illustrates the loss of utility service in the State of Arkansas. The day after the earthquake, over 175,000 of the one million households in the state are without potable water and over 95,000 households are without electric power. After one week some households see renewed service, though hundreds of thousands of people are still without service. With no utilities available in their homes, many residents that did not experience severe structural damage to their homes may be displaced, dramatically increasing the number of people requiring public shelter. For more information on damage estimates for the

[9] See footnote (3).
[10] See footnote (3).

State of Arkansas, please refer to Appendix V for detailed impact assessment results and see Appendix VIII for maps of damage and functionality losses.

Illinois New Madrid Seismic Zone Scenario

A rupture on the northeast extension of the New Madrid Fault produces intense shaking in southern Illinois. Forty counties near the source of seismic activity are identified as critical counties and are expected to incur high levels of damage. These counties are highlighted in Figure 13 and are listed below:

- Alexander
- Bond
- Calhoun
- Clark
- Clay
- Clinton
- Crawford
- Edwards
- Effingham
- Fayette
- Franklin
- Gallatin
- Greene
- Hamilton
- Hardin
- Jackson
- Jasper
- Jefferson
- Jersey
- Johnson
- Lawrence
- Macoupin
- Madison
- Marion
- Massac
- Monroe
- Montgomery
- Perry
- Pope
- Pulaski
- Randolph
- Richland
- Saint Clair
- Saline
- Union
- Wabash
- Washington
- Wayne
- White
- Williamson

There are roughly 3.3 million buildings in the State of Illinois; far more than the other states in the eight-state region. This is in large part due to the substantial number of buildings in Chicago, Illinois, located in the northeastern portion of the state. These buildings are not likely to be damaged from an earthquake, however, and may skew perceptions of damaged building estimates. There are nearly 17,000 cases of complete damage and nearly 30,000 cases of at least moderate damage. No buildings incur complete damage, which is the rare collapse of a structure. More commonly, complete damage includes critical damage to structural connections, significant lateral displacement of structural systems and other damage that renders a building uninhabitable. In some cases damage is severe enough to cause collapse during aftershocks even if it does not occur during the main event.

When compared to the 3.3 million buildings in Illinois, this is roughly 1% of all buildings. Though when considering the 26,000 cases of at least moderate damage in the 40 critical counties, which includes only 500,000 buildings, this equates to over 5% of all buildings.

As with many other states, residential buildings experience the majority of building damage. Single family homes and other residential buildings account for all but 200 cases of complete damage and 98% of all at least moderate damage throughout the state, as shown in Table 21. Damage is further classified by building type in Table 22. Wood frame structures account for over 35% of all moderate, extensive and complete damage cases, while over 45% of all complete damage occurs with this building type. Several thousand unreinforced masonry buildings and mobile homes experience complete damage, though extensive and moderate damage levels occur even more.

Table 21: NMSZ Event Building Damage by Occupancy Type for the State of Illinois

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**At Least Moderate Damage**	**Complete Damage**
Single Family	2,780,853	16,999	11,586
Other Residential	416,473	12,046	5,087
Commercial	41,905	352	140
Industrial	7,466	40	11
Other	4,515	46	36
Total	3,251,212	29,483	16,860

Table 22: NMSZ Event Building Damage by Building Type for the State of Illinois

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	2,315,085	21,686	6,150	2,750	7,819
Steel	16,145	656	193	15	60
Concrete	31,516	917	250	44	215
Precast	5,382	178	71	8	26
Reinforced Masonry	5,776	78	24	2	15
Unreinforced Masonry	638,209	38,777	7,430	1,176	4,117
Mobile Home	107,166	23,298	9,620	1,750	4,608
Total	3,119,279	85,590	23,738	5,745	16,860

Numerous essential facilities are damaged and are not operational in the days after the earthquake, all of which occurs in southern Illinois and the critical counties in particular. There are 83 at least moderately damaged schools with 60 of those being completely damaged. All of these schools are in the southernmost counties in Illinois, and since schools frequently function as shelters for displaced people, southern Illinois is likely to be without some of its sheltering facilities. Nearly 40 fire stations and 20 police stations are damaged while 80 fire stations and over 45 police stations are not operational the day after the earthquake, as shown in Table 23. This lack of functioning facilities will make the organization of immediate emergency response workers difficult, since there will be limited facilities available to coordinate these efforts.

The functional capacity of most transportation lifelines is reduced, particularly in the critical counties. There are over 250 at least moderately damaged bridges that will not be functioning at full capacity, as shown in Table 24. With 71 bridges experiencing complete damage, and all of these bridges in the southernmost counties, this portion of the state will have very limited mobility when it comes to the movement of people and aid into and out of the region. Additionally, 30 airports, 20 ports and 10 railway facilities are at least moderately damaged and not operational the day after the earthquake. For further information on transportation damage and functionality, please refer to Appendix V.

Table 23: NMSZ Event Essential Facilities Damage for the State of Illinois[11]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	249	3	1	217
Schools	5,722	83	60	5,464
EOCs	149	2	2	145
Police Stations	1,044	21	15	997
Fire Stations	1,725	38	32	1,645

Table 24: NMSZ Event Highway Bridge Damage for the State of Illinois[12]

Highway Bridge Damage Assessments				
	Total No. of Bridges	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage>50%)**	**Functionality >50% at Day 1**
40 Critical Counties	6,554	264	71	6,293
Remaining Counties	16,300	0	0	16,300
Total State	22,854	264	71	22,593

Utility lifeline damage and functionality is exemplified by waste water facilities estimates in Table 25. There are thousands of waste water facilities in the State of Illinois and roughly 2,000 in the critical counties. Over 450 facilities are at least moderately damaged, which equates to 20% of all facilities in the critical counties. Nearly 1,000 facilities in this same area are not functioning the day after the earthquake which will substantially limit the service provided to customers in southern Illinois. Additionally, nearly 60 electric power facilities are damaged and approximately 130 non-operational at day 1. Communication facilities also show a high frequency of damage in the critical counties with 1,450 at least moderately damaged facilities, or which is roughly 20% of the 7,500 facilities in that area.

Table 25: NMSZ Event Waste Water Facilities Damage for the State of Illinois[13]

Waste Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage>50%)**	**Functionality >50% at Day 1**
40 Critical Counties	2,221	461	8	1,246
Remaining Counties	7,168	0	0	7,168
Total State	9,389	461	8	8,414

In addition to the significant damage to facilities, utility distribution lines show thousands of breaks and leaks as well. The local potable water distribution network incurs nearly

[11] See footnote (3).
[12] See footnote (3).
[13] See footnote (3).

5,500 breaks and leaks, over nearly 165,000 miles of pipe. Furthermore, regional pipelines that transmit natural gas and oil nationwide incur numerous leaks in southern Illinois and may inhibit the transport of these commodities to regions far outside the NMSZ. Damage to pipelines, especially in the local distribution networks, interrupts services for many customers, as shown in Table 26. The day after the earthquake, nearly 71,000 households are without potable water and nearly 70,000 households are left without electric power. Even after one week, 43,000 customers are without potable water and nearly 25,000 households without power. As mentioned earlier, this large number of households without critical services will increase the number of people seeking public shelter, even if their homes are not structurally damaged or condemned. For more information on direct damage and functionality of Illinois infrastructure, please refer to Appendix V for detailed impact assessment results and Appendix VIII for maps of damage and functionality.

Table 26: NMSZ Event Utility Service Interruptions for the State of Illinois

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	4,591,779	70,781	56,532	43,091	26,770	0
Electric Power		69,641	48,139	24,340	6,678	83

Indiana New Madrid Seismic Zone Scenario

The northeast segment of the New Madrid Fault produces a moderate level of shaking in the southwestern counties of Indiana. A total of 11 counties are identified in this southwest portion of the state and are considered critical in that they are likely to incur the majority of the damage experienced in the state. These counties are highlighted in Figure 14 and are listed on the following page:

- Daviess
- Dubois
- Gibson
- Greene
- Knox
- Pike
- Posey
- Spencer
- Sullivan
- Vanderburgh
- Warrick

There are over 1.9 million buildings in the State of Indiana and most remain undamaged by the NMSZ event. Table 27 shows that nearly 6,500 buildings, or roughly one-third of 1% of all Indiana buildings, incur at least moderate damage. Of the 160,000 buildings in the critical counties, only 3,500, or 2% of all buildings in the critical counties, incur at least moderate damage. This also indicates that damage from the NMSZ earthquake is not confined to the critical counties as is the case with some other scenarios. What is consistent with other scenarios, however, is that the majority of damage occurs in residential structures, as shown in Table 27. Building damage by building type is illustrated in Table 28. Most cases of moderate and extensive damage are incurred by unreinforced masonry and mobile homes, which is consistent with other scenarios that show only moderate levels of shaking, such as Alabama. In comparison with other states in the eight-state region, Indiana experiences very little damage to buildings.

Table 27: NMSZ Event Building Damage by Occupancy Class in the State of Indiana

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,675,434	2,814	2
Other Residential	229,169	3,189	0
Commercial	19,034	154	0
Industrial	4,317	37	0
Other	4,102	266	0
Total	1,932,056	6,460	2

Table 28: NMSZ Event Building Damage by Building Type for the State of Indiana

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,388,618	7,908	150	0	0
Steel	8,288	463	191	13	0
Concrete	2,618	126	39	1	0
Precast	2,862	158	90	7	0
Reinforced Masonry	1,737	35	14	1	0
Unreinforced Masonry	337,716	18,051	2,823	109	2
Mobile Home	140,340	16,674	2,994	28	0
Total	1,882,179	43,415	6,301	159	2

Damage to essential facilities and transportation lifelines show similar results, in so far as damage and functionality losses are very uncommon or nonexistent. As shown in Table 29, no facilities are expected to incur at least moderate damage, though less severe damage forms are possible. Such forms of damage may include minor cracking to concrete and masonry structures. There is some loss of functionality, all of which occurs in the 11 critical counties. Schools show the greatest loss of functionality, with 56 schools not operational the day after the earthquake. Another nine hospitals, 18 fire stations and six police stations are also not functioning at this same point in time. Transportation lifeline infrastructure items are similar in that there are no cases of moderate damage. In contrast to essential facilities functionality, transportation components show no loss of functionality.

Utility facilities do not show any cases of moderate or more severe damage, as is the case with essential facilities and transportation lifelines. Furthermore, there is no loss of functionality, even immediately after the earthquake. While utility facilities show very little damage, utility pipelines show numerous cases of breaks and leaks, as shown in Table 30. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at 728 and 753, respectively. Local natural gas lines, however, show the greatest break and leak rates per length of pipe at roughly 0.014 leaks/mile and breaks/mile (roughly 1 leak/break every 70 miles). In addition, local and regional damage to natural

gas lines can be combined for a total state damage estimate of 650 leaks and 652 breaks over the combined length of 54,746 miles of natural gas pipeline.

Table 29: NMSZ Event Essential Facilities Damage for the State of Indiana[14]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	175	0	0	166
Schools	2,686	0	0	2,630
EOCs	51	0	0	50
Police Stations	474	0	0	468
Fire Stations	1,210	0	0	1,192

Table 30: NMSZ Event Pipeline Damage for the State of Indiana

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	111,394	753	728
Waste Water - Local	66,836	596	576
Natural Gas - Regional	10,188	13	36
Natural Gas - Local	44,558	637	616
Oil - Regional	4,625	17	60

Table 31: NMSZ Event Utility Service Interruptions for the State of Indiana

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	2,336,306	44,115	34,798	11,075	0	0
Electric Power		0	0	0	0	0

The damage to local distribution networks cuts off service for tens of thousands of customers. Table 31 illustrates that over 44,000 households are without potable water service the day after the earthquake, while all electric power service is retained throughout the state. Electric power lines are presumed to be above ground and less likely to incur damage from moderate ground shaking, unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation. As a result of the low level of shaking, electric power service is not likely to be interrupted for residences in Indiana, even in the first few days following the earthquake.

For further information on the earthquake impact assessment results for direct damage in the State of Indiana, please refer to Appendix V. Additional maps showing the distribution of damage can be found in Appendix VIII.

[14] See footnote (3).

Indiana Wabash Valley Seismic Zone Scenario

The WVSZ scenario in the State of Indiana employs the same set of critical counties as the NMSZ scenario. The southwestern-most counties in Indiana experience the most intense shaking for both scenario events, thus the same set of counties is used. For more information on the shaking generated by these to events in the State of Indiana, please refer to Appendix I. The critical counties for the State of Indiana are illustrated in Figure 14 and are listed below:

- Daviess
- Dubois
- Gibson
- Greene
- Knox
- Pike
- Posey
- Spencer
- Sullivan
- Vanderburgh
- Warrick

The WVSZ event causes several thousand cases of complete damage, as well as moderate and severe damage, to the more than 1.9 million buildings in Indiana. Of the roughly 9,000 completely damaged structures, 96% are residential, with over 85% of these being single family homes. Table 32 illustrates the distribution of building damage by occupancy type. Furthermore, more than 8,600 completely damaged buildings are located in the 11 critical counties in southwest Indiana. Moderate and severe damage is incurred by another 8,000 structures, though only 1,500 of these damage cases occur in the critical counties. This indicates that damage is not confined to the southwestern tip of Indiana, but occurs in counties outside that area, such as Perry, Crawford, Orange, Lawrence, Martin, Monroe, Owen, Clay, Vigo and others.

The WVSZ event produces higher levels of shaking than the NMSZ event, and as a result causes thousands of more cases of damage, particularly complete damage. The combination of liquefaction data and more intense shaking contributes significantly to the large number of wood frame building complete damage cases. Approximately 70% of all complete damage is experienced by wood frame structures, while another 20% can be attributed to unreinforced masonry buildings. Moderate and extensive damage states show large numbers of damaged unreinforced masonry structures and mobile homes, though very little wood frame damage is estimated. Of the more than 7,600 cases of moderate and extensive damage, greater than 6,600 cases, or 87%, of the damage, can be attributed to unreinforced masonry and mobile homes. Table 33 shows the distribution of building damage by building type.

Though thousands of buildings are damaged by a WVSZ event, essential facilities incur very little damage. Table 34 shows that no essential facilities experience at least moderate damage, though it is likely that some of these facilities will incur some form of minor damage from the WVSZ event. This may include minor cracking of concrete and masonry or minor joint damage, though nothing severe enough to compromise the operational capabilities of the facilities. While estimates show no moderate damage, the functionality of some facilities, particularly in the critical counties, is reduced from this event. There are 20 schools, 15 fire stations, eight police stations and one hospital that are not functional the day after the earthquake. This is likely to limit the emergency response

capabilities of such services in the hours immediately after the event, especially in the extreme southwestern counties of Indiana.

Table 32: WVSZ Event Building Damage by Occupancy Class for the State of Indiana

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,675,434	5,315	7,464
Other Residential	229,169	2,068	1,161
Commercial	19,034	200	90
Industrial	4,317	30	15
Other	4,102	31	224
Total	1,932,056	7,644	8,954

Table 33: WVSZ Event Building Damage by Building Type for the State of Indiana

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,370,489	19,342	515	24	6,305
Steel	8,545	222	83	4	101
Concrete	2,655	72	13	0	44
Precast	2,912	107	46	2	51
Reinforced Masonry	1,717	41	15	0	14
Unreinforced Masonry	330,681	21,176	4,936	227	1,683
Mobile Home	148,359	9,140	1,767	13	756
Total	1,865,358	50,100	7,374	270	8,954

Table 34: WVSZ Event Essential Facilities Damage for the State of Indiana[15]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	175	0	0	174
Schools	2,686	0	0	2,666
EOCs	51	0	0	49
Police Stations	474	0	0	466
Fire Stations	1,210	0	0	1,195

Despite the moderate level of shaking in several southwestern Indiana counties, most transportation lifeline components remain largely undamaged by the WVSZ event. All highway bridges remain functional even in the days immediately after the earthquake and none of these bridges incur moderate or more severe damage. All railway bridges, as well as railway and port facilities, remain undamaged and operational. Five airports in southwestern Indiana, however, incur moderate damage, which leaves two airports non-

[15] See footnote (3).

operational in the days immediately after the event. These estimates are not shown here but can be found in Appendix V.

Numerous types of utility lifelines incur damage, including hundreds of communication facilities, as shown in Table 35. There are nearly 2,500 communication facilities in the 11 critical counties and 432 of these facilities experience at least moderate damage. Three facilities outside the area in Vigo County also incur at least moderate damage. Of these 435 damaged facilities, only 131 are not functioning the day after the event. In addition to communication facilities damage, 23 electric power facilities experience at least moderate damage, and 53 of these facilities are not operational the day after the event. Furthermore, 22 waste water facilities are not functioning immediately after the earthquake.

Table 35: WVSZ Event Communication Facilities Damage for the State of Indiana[16]

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	2,490	432	0	2,359
Remaining Counties	19,189	3	0	19,189
Total State	21,679	435	0	21,548

This dramatic loss of functionality in the southwestern counties of Indiana will severely limit service to area customers. As illustrated in Table 36, tens of thousands of people are without critical utility services in the days and weeks following the WVSZ event. Over 42,000 households are without potable water the day after the earthquake, while nearly 27,000 are still without water after one week. Electric power is cut off for nearly 15,000 people immediately after the event with over 4,000 still without power after a week. A lack of these services will likely prevent residents from staying in their homes and increase the number of people seeking public shelter. For more information on WSVZ impact assessment results, please refer to Appendix V.

Table 36: WVSZ Event Utility Service Interruptions for the State of Indiana

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	2,336,306	42,022	31,248	26,786	18,504	0
Electric Power		14,994	9,419	4,185	1,169	19

[16] See footnote (3).

Kentucky New Madrid Seismic Zone Scenario

The northeast fault segment generates substantial shaking in western Kentucky. As a result 25 counties are identified in that area and are expected to incur the majority of the damage from a NMSZ earthquake. These critical counties are highlighted in Figure 15 and are also listed below:

- Ballard
- Caldwell
- Calloway
- Carlisle
- Christian
- Crittenden
- Daviess
- Fulton
- Graves
- Hancock
- Henderson
- Hickman
- Hopkins
- Livingston
- Logan
- Lyon
- McCracken
- McLean
- Marshall
- Muhlenberg
- Ohio
- Todd
- Trigg
- Union
- Webster

The State of Kentucky experiences substantial damage to its building stock of nearly 1.5 million buildings, most of which is confined to the western half of the state. Table 37 illustrates the number of building damaged by the NMSZ event. Nearly 30,000 buildings are completely damaged and another 53,000 buildings experience moderate or severe damage. All but roughly 150 cases of complete damage occur in the critical counties and approximately 95% of all moderate and severe damage occurs in these counties. As with many other scenarios, residential structures comprise the majority of the damage. Nearly 98% of all complete damage and over 99% of all moderate and severe damage occurs to single family homes and other residential buildings. This percentage of damage is proportional to the inventory; however, roughly 98% of the building stock is residential construction. As mentioned earlier, other residential structures are most commonly multi-unit dwellings.

Table 37: NMSZ Event Building Damage by Occupancy Type for the State of Kentucky

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,159,114	39,150	18,768
Other Residential	292,873	13,050	9,673
Commercial	16,431	306	475
Industrial	3,002	48	53
Other	1,900	34	60
Total	1,473,320	52,588	29,029

Building damage by building type is shown in Table 38. Nearly half of all complete damage occurs in wood frame structures, with mobile homes comprising 30% of complete damage and unreinforced masonry (URM) representing slightly less than 30%. Though nearly 14,000 cases of complete damage occur to wood frame structures, this only represents 1.3% of all wood frame buildings in Kentucky. The roughly 6,200 URMs and 8,800 mobile homes that are completely damaged represent a much higher portion of

their respective inventories at 3.9% of all URMs and 3.6% of all mobile homes. When comparing these percentages, it is evident that URMs are more vulnerable to damage despite having fewer actual instances of complete damage. The same type of comparison can be done for moderate and extensive damage. In this case, the 11,800 instances of moderate and severe damage to mobile homes represents 4.8% of all mobile homes in Kentucky, which is the greatest proportion of inventory damaged at this level by far. Only 3.4% of wood frame buildings and 2.7% of URMs are damaged at these severity levels.

Table 38: NMSZ Event Building Damage by Building Type for the State of Kentucky

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	992,135	18,737	24,772	11,617	13,726
Steel	6,430	264	93	39	201
Concrete	1,782	51	22	15	58
Precast	1,907	74	42	19	69
Reinforced Masonry	1,109	20	13	10	39
Unreinforced Masonry	137,881	8352	2,434	1,720	6,161
Mobile Home	197,127	25935	7,952	3,840	8,775
Total	1,338,371	53,433	35,328	17,260	29,029

Essential facilities experience substantial damage, particularly in the westernmost counties in Kentucky. Nearly 100 schools are at least moderately damaged, with roughly 80 being completely damaged. This leaves nearly all schools in Fulton, Hickman, Carlisle, Ballard, McCracken, Graves, Calloway and Marshall Counties completely damaged and non functional for a significant period after the earthquake. Schools are often used as public shelters, though with so many damaged in western Kentucky displaced people will need to be housed elsewhere. Emergency services also suffer tremendous losses in western Kentucky. There are 77 at least moderately damaged fire stations and 23 police stations similarly damaged, as shown in Table 39. In addition, 107 fire stations and 34 police stations, all in the western Kentucky, are not operational the day after the event. With 17 hospitals in that same area not operational, all emergency response services will be impaired.

Table 39: NMSZ Event Essential Facilities Damage for the State of Kentucky[17]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	135	6	4	118
Schools	1,846	98	79	1,713
EOCs	0	0	0	0
Police Stations	407	23	19	373
Fire Stations	1,066	77	61	959

[17] See footnote (3).

Transportation lifelines in the critical counties incur substantial damage and are likely to make travel within the region and access to the region from the outside difficult. There are approximately 200 damaged bridges in western Kentucky and nearly 50 of those are completely damaged, indicating they will not regain functionality for a significant period of time (see Table 40). The majority of these completely damaged bridges are in Fulton, Hickman, Carlisle, Ballard, McCracken and Graves Counties. In addition, there are 14 completely damaged port facilities, with roughly half on the Mississippi and half on the Ohio Rivers. Also, 19 airports are moderately or more severely damaged with 13 non operational immediately after the earthquake.

Table 40: NMSZ Event Highway Bridge Damage for the State of Kentucky[18]

Highway Bridge Damage Assessments				
	Total No. of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	2,173	197	46	1,974
Remaining Counties	4,632	0	0	4,630
Total State	6,805	197	46	6,604

Table 41: NMSZ Event Waste Water Facilities Damage for the State of Kentucky[19]

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	1,561	523	81	764
Remaining Counties	7,530	0	0	7,530
Total State	9,081	523	81	8,294

In addition, numerous utility lifelines are damaged and not functioning in the critical counties. As shown in Table 41 more than 500 waste water facilities incur at least moderate damage and 81 of those facilities are completely damaged. In the days immediately after the earthquake, approximately 800 waste water facilities in the critical counties are not functioning, which will severely limit service to many residents in western Kentucky. Electric power facilities in the critical counties are also heavily damaged with 132 facilities incurring at least moderate damage and 232 of the 463 electric power facilities not operational immediately after the event. In addition, 850 communication facilities are out of service in the days after the earthquake.

With such extensive functional losses in the critical counties, tens of thousands of households are without crucial services. Table 42 illustrates the numbers of households without potable water and electric power in the days and weeks after the NMSZ earthquake. The day after the event, nearly 109,000 households are without water and 77,000 are without electricity. A large portion of households regain service within the

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[18] See footnote (3).
[19] See footnote (3).

first week, but there are still 67,000 households without water in the most heavily damaged areas. With such extended service losses in western Kentucky, some residents whose homes are not heavily damaged may be forced to leave due to a lack of drinking water and electricity. For more information on direct damage and functional losses in the State of Kentucky, please refer to Appendix V for detailed assessment results and to Appendix VIII for damage and functionality maps.

Table 42: NMSZ Event Utility Service Interruptions for the State of Kentucky

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	1,590,647	108,556	92,742	66,608	38,964	0
Electric Power		77,263	60,273	36,450	11,464	86

Mississippi New Madrid Seismic Zone Scenario

The NMSZ event on the southwest segment of the fault generates intense shaking in Mississippi's northern counties. As a result, 25 counties are identified as critical and most of the damage incurred by the State of Mississippi is expected to occur in this set of counties. These 25 critical counties are highlighted in Figure 16 and are listed below:

- Alcorn
- Benton
- Bolivar
- Calhoun
- Chickasaw
- Coahoma
- Desoto
- Grenada
- Itawamba
- Lafayette
- Lee
- Marshall
- Monroe
- Panola
- Pontotoc
- Prentiss
- Quitman
- Sunflower
- Tallahatchie
- Tate
- Tippah
- Tishomingo
- Tunica
- Union
- Yalobusha

Buildings in Mississippi are expected to incur moderate damage in the northern portion of the state, with limited cases of complete damage which are limited to the critical counties. There are 7,300 buildings that are estimated to incur complete damage, all of which are in the 25 critical counties. Approximately 35,000 of the 39,000 moderate and severe damage cases occur in the critical counties. Table 43 illustrates the distribution of building damage by occupancy type. Nearly all complete and moderate/severe damage is experienced by residential construction, leaving 45,000 of the one million residential structures in Mississippi damaged.

As with many other NMSZ states, wood frame buildings and mobile homes are the most common structural systems. What is uncommon, however, is the small percentage of building inventory belonging to URMs. In Mississippi, approximately 5% of the total building inventory is URM construction. Nearly half of all complete damage occurs in wood frame buildings even though only 25% of moderate damage is incurred by this type of construction. Approximately 60% of all moderate damage is attributed to mobile homes, as shown in Table 44. It is also relevant to note that while steel, concrete and

precast (concrete) structures are a much smaller portion of the building stock in Mississippi, approximately 15% of each of these building types experiences at least moderate damage, while only 1.4% of all wood frame buildings incurs at least moderate damage.

Table 43: NMSZ Event Building Damage by Occupancy Type for the State of Mississippi

General Occupancy Type Damage			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	793,953	11,343	3,881
Other Residential	212,185	26,741	3,094
Commercial	8,062	705	190
Industrial	1,657	466	112
Other	1,478	127	23
Total	1,017,335	39,382	7,300

Table 44: NMSZ Event Building Damage by Building Type for the State of Mississippi

Building Damage by Building Type					
Building Type	None	Slight	Moderate	Extensive	Complete
Wood	703,568	50807	7,092	189	3,335
Steel	2,512	297	296	269	181
Concrete	906	102	84	63	30
Precast	955	104	113	78	40
Reinforced Masonry	494	39	36	21	12
Unreinforced Masonry	44,187	6104	3,553	1,531	764
Mobile Home	133,149	27429	16,731	9,326	2,938
Total	885,771	84,882	27,905	11,477	7,300

The northernmost counties in Mississippi are greatly affected by damage and functional losses to essential facilities. Over 100 schools experience at least moderate damage and over 150 are not functioning the day after the earthquake, as shown in Table 45. Nearly all of these damaged schools are located in Desoto, Tunica, Tate, Marshall and Benton Counties. Additionally, Lafayette, Union, Tippah, Alcorn, and Prentiss Counties experience substantial functional loss to schools immediately after the earthquake. There are 81 at least moderately damaged fire stations and nearly 130 not functioning the day after the earthquake. Hospitals in northwest Mississippi are not functioning as well, with 34 facilities in the critical counties along with Leflore, Montgomery, Webster, Lowndes and Oktibbeha Counties. Not only will this region be without medical care services for those injured by the earthquake, but care for current patients will likely require transport to fully functioning facilities outside the critical counties.

Transportation lifelines experience damage primarily in northwestern Mississippi. Table 46 illustrates that over 70 highway bridges are damaged and 65 are not functioning the day after the earthquake. Most of these non-functioning bridges are in Desoto, Tunica, Tate and Marshall Counties. Five airports in northwest Mississippi incur at least

moderate damage, though they are expected to remain fully functional. In some cases damage to structures may not affect functionality of the facility. Using airports as an example, some portion of the facility may be damaged, though enough of the facility's structure remains undamaged so that the facility can remain operational, despite some damage to one portion of the facility.

Table 45: NMSZ Event Essential Facilities Damage for the State of Mississippi[20]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	123	11	2	89
Schools	1,281	110	10	1,130
EOCs	37	1	0	35
Police Stations	365	30	2	322
Fire Stations	984	81	3	856

Table 46: NMSZ Event Highway Bridge Damage for the State of Mississippi[21]

Highway Bridge Damage Assessments				
	Total No. Of Bridges	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
25 Critical Counties	5,043	73	0	4,978
Remaining Counties	11,893	0	0	11,893
Total State	16,936	73	0	16,871

Table 47: NMSZ Event Communication Facilities Damage for the State of Mississippi[22]

Communication Damage Assessments				
	Total No. of Communication Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
25 Critical Counties	2,553	290	0	2,553
Remaining Counties	6,663	0	0	6,663
Total State	9,216	290	0	9,216

Utility lifelines experience substantial losses in the critical counties, especially in the northwestern-most critical counties. Damage to communication facilities is shown in Table 47, which illustrates that nearly 300 communication facilities, all in Desoto and Tate Counties, are at least moderately damaged. Damage to these facilities is not severe enough to cause a substantial loss of functionality, however. There are nearly 300 waste water facilities and 48 electric power facilities that are not operational immediately

[20] See footnote (3).
[21] See footnote (3).
[22] See footnote (3).

following the earthquake. Most of these facilities are located in Desoto, Tate, Tunica and the surrounding counties.

There are approximately one million households, or residences, in the State of Mississippi and nearly 42,000 of those are without potable water the day after the earthquake. In addition, 33,000 are without electricity. Only 2,000 households have potable water service restored after a week, though 26,000 have electricity restored in that same period of time. A lack of potable water service for an extended period of time, as shown in Table 48, may force some families to leave their homes, even if the home is not significantly damaged. For more information on direct damage and functional losses in the State of Mississippi, please refer to Appendix V for detailed assessment results and to Appendix VIII for damage and functionality maps.

Table 48: NMSZ Event Utility Service Interruptions for the State of Mississippi

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	1,046,434	41,790	40,256	39,752	28,749	0
Electric Power		32,601	18,416	6,452	1,276	44

Missouri New Madrid Seismic Zone Scenario

The NMSZ event on the central thrust fault produces substantial shaking in southeast Missouri. The counties that experience the most significant shaking are designated as critical counties and much of the damage incurred is anticipated to occur in that set of counties. There are a total of 45 critical counties in addition to the City of St. Louis in Missouri, which are highlighted in Figure 17 and listed below:

- Audrain
- Bollinger
- Boone
- Butler
- Callaway
- Cape Girardeau
- Carter
- Cole
- Crawford
- Dent
- Douglas
- Dunklin
- Franklin
- Gasconade
- Howell
- Iron
- Jefferson
- Lincoln
- Madison
- Maries
- Miller
- Mississippi
- Montgomery
- New Madrid
- Oregon
- Osage
- Ozark
- Pemiscot
- Perry
- Phelps
- Pike
- Pulaski
- Reynolds
- Ripley
- St. Charles
- Ste. Genevieve
- St. Francois
- St. Louis
- St. Louis City
- Scott
- Shannon
- Stoddard
- Texas
- Warren
- Washington
- Wayne

The City of St. Louis is considered independently of St. Louis County. This distinction means that there are only 45 critical counties in the State of Missouri and one critical city. For the purposes of this report, however, all critical areas will be referred to as critical counties, with St. Louis City as its own county for a total of 46, rather than 45, critical counties.

Missouri is one of the most heavily damaged states of all the states in the NMSZ region. Of the 1.9 million buildings in Missouri, nearly 122,000 buildings are at least moderately damaged, which equates to 6.5% of all buildings in Missouri. This is a much higher margin than the 1-2% estimated in many other states. Table 49 shows that nearly 98% of all cases of complete damage are experienced by residential structures. The same is true for the at least moderate damage level. In addition, all complete damage and 98% of at least moderate damage occur in the 46 critical counties. The low level of shaking outside the critical counties causes roughly 1,800 cases of moderate damage, though most is confined to the critical counties in southeast Missouri.

Wood frame structures, URMs and mobile homes are the three building types which experience the most damage. Over 15,000 wood frame structures are completely damaged and nearly 34,000 are at least moderately damaged. This equates to 1.3% and 2.8% of all wood frame building in Missouri, respectively. The 9,600 mobile homes that are completely damaged comprise 5% of all of Missouri's mobile homes, while the 22,500 at least moderately damaged mobile homes represent 11.7% of all mobile homes in the state. Table 50 also shows that 27,300 URMs experience at least moderate damage and comprise 7.2% of all URMs in Missouri.

Table 49: NMSZ Event Building Damage by Occupancy Type for the State of Missouri

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**At Least Moderate Damage**	**Complete Damage**
Single Family	1,472,235	55,807	23,860
Other Residential	272,089	26,748	12,179
Commercial	20,433	1,560	651
Industrial	2,872	226	80
Other	2,916	226	121
Total	1,770,545	84,567	36,891

Table 50: NMSZ Event Building Damage by Building Type for the State of Missouri

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,108,809	40,945	13,655	4,808	15,090
Steel	6,800	601	360	109	298
Concrete	2,166	156	70	27	84
Precast	2,291	179	129	41	97
Reinforced Masonry	1,493	121	77	20	69
Unreinforced Masonry	317,999	34,151	11,730	3,929	11,686
Mobile Home	149,399	20,868	8,177	4,544	9,567
Total	1,588,957	97,021	34,198	13,478	36,891

Damage and functional losses to essential facilities in Missouri are most prominent in the extreme southeastern counties, where shaking is most intense. Nearly 200 schools and

over 100 fire stations are at least moderately damaged. In addition, numerous facilities are completely damaged and will not be operational for an extended period of time. The day after the earthquake, 37 hospitals, nearly 300 schools, 67 police stations and 135 fire stations are not functioning. The majority of these facilities are located in Dunklin, Pemiscot, New Madrid, Butler, Stoddard, Mississippi, Ripley, Wayne and Cape Girardeau Counties, as well as the St. Louis area. Much of southeast Missouri is without local emergency response services and medical care, since a majority of the essential facilities are non-operational in the days following the earthquake.

The extensive damage to transportation lifelines makes traveling within southeast Missouri incredibly difficult. As shown in Table 52, over 650 highway bridges are completely damaged and over 1,350 bridges are not operational immediately after the earthquake. Most bridges are in the counties that experience substantial, essential facilities functional losses and these counties were listed previously. Numerous railway, port and airport facilities are also damaged. This level of damage leads to 26 airports, 25 ports and 16 railway facilities out of service in the days immediately following the event. With much of this damage and functional loss occurring in southeast Missouri, not only will it be difficult to travel within this area, but it will be much harder to get relief workers and aid into the area and injured or displaced families out of the area.

Table 51: NMSZ Event Essential Facilities Damage for the State of Missouri[23]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	160	8	3	123
Schools	2,817	185	85	2,530
EOCs	33	7	4	25
Police Stations	654	61	32	587
Fire Stations	1,399	116	48	1,264

Table 52: NMSZ Event Highway Bridge Damage for the State of Missouri[24]

Highway Bridge Damage Assessments				
	Total No. Of Bridges	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
46 Critical Counties	7,803	1,363	659	6,447
Remaining Counties	13,962	0	0	13,962
Total State	21,765	1,363	659	20,409

[23] See footnote (3).
[24] See footnote (3).

Table 53: NMSZ Event Potable Water Facility Damage for the State of Missouri[25]

Potable Water Facilities Damage Assessments				
	Total No. of Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
46 Critical Counties	3,413	758	48	2,756
Remaining Counties	5,186	0	0	5,186
Total State	8,599	758	48	7,942

Utility lifelines are heavily damaged as well, particularly in southeast Missouri. Table 53 illustrates the damage and functional loss of potable water facilities. Approximately 50 potable water facilities are completely damaged and over 650 facilities are not operating the day after the event. Communication facilities also incur major damage, with nearly 1,600 at least moderately damaged facilities and 865 non-functioning facilities immediately after the earthquake. In addition, over 100 electric power facilities are down and 63 natural gas facilities are not operating. Most of southeast Missouri is so heavily damaged that nearly all utility services are down in the days after the event.

This massive loss of functionality in utility lifelines leads to hundreds of thousands of service interruptions, as shown in Table 54. Nearly 150,000 households are without potable water and 100,000 without electricity immediately after the earthquake. After one week, many customers will see service restored, though 80,000 households are still without water and 40,000 without electricity. Even after one month, tens of thousands of customers are without water, electricity or both. Such major lapses in service will most likely prevent people from remaining in their homes causing them to seek temporary, or even long-term, shelter at public sheltering locations. For more information on direct damage and functional losses in the State of Missouri, please refer to Appendix V for detailed assessment results and to Appendix VIII for damage and functionality maps.

Table 54: NMSZ Event Utility Service Interruptions for the State of Missouri

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	2,194,594	146,368	115,391	79,848	77,818	38,426
Electric Power		100,141	70,720	39,499	12,955	121

Tennessee New Madrid Seismic Zone Scenario

An event on the southwest segment of the eastern fault in the NMSZ produces significant shaking in western Tennessee. As a result, 37 critical counties in that region are identified as being are likely to incur the most damage of all counties throughout the state. These 37 critical counties are highlighted in Figure 18 and are also listed below:

[25] See footnote (3).

- Benton
- Carroll
- Cheatham
- Chester
- Crockett
- Davidson
- Decatur
- Dickson
- Dyer
- Fayette
- Gibson
- Giles
- Hardeman
- Hardin
- Haywood
- Henderson
- Henry
- Hickman
- Houston
- Humphreys
- Lake
- Lauderdale
- Lawrence
- Lewis
- McNairy
- Madison
- Maury
- Montgomery
- Obion
- Perry
- Robertson
- Shelby
- Stewart
- Tipton
- Wayne
- Weakley
- Williamson

The State of Tennessee experiences the most damage of all of the states in the NMSZ region. There are nearly 82,000 completely damaged buildings and another 176,000 moderately or severely damaged buildings for a total of approximately 258,000 damaged buildings. This represents over 12% of all the buildings in the State of Tennessee and the largest percentage of damaged building stock by far, when compared to the other seven NMSZ states. As shown in Table 55, approximately 95% of complete damage occurs in residential buildings. Over 98% of all moderate and severe damage is experienced by residential buildings. It is also relevant to note that while damage to commercial structures comprises a very small portion of overall damage, the 5,300 at least moderately damaged commercial structures represent 25% of all commercial buildings in the State of Tennessee. Additionally, all complete damage occurs in the 37 critical counties and nearly 99% of moderate and severe damage occurs there as well.

Table 55: NMSZ Event Building Damage by Occupancy Type for the State of Tennessee

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,720,196	142,729	58,255
Other Residential	330,518	31,012	19,340
Commercial	20,582	1,882	3,461
Industrial	3,553	286	520
Other	2,337	170	331
Total	2,077,186	176,079	81,907

Table 56: NMSZ Event Building Damage by Building Type for the State of Tennessee

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,255,670	180,779	112,188	19,319	34,888
Steel	6,045	222	171	353	1,610
Concrete	1,786	39	68	135	417
Precast	1,934	57	66	139	497
Reinforced Masonry	1,125	15	36	84	312
Unreinforced Masonry	138,979	7,893	7,597	11,117	29,385
Mobile Home	199,367	25,289	13,577	11,229	14,797
Total	1,604,906	214,294	133,703	42,376	81,907

Of the 2.1 million buildings in the State of Tennessee, 1.6 million, or 77%, are of wood frame construction. Mobile homes and URMs comprise 13% and 9%, respectively. The city of Memphis, TN, is a major urban center in the Central U.S., and includes many unreinforced masonry buildings. Memphis, TN, is near the course of seismic activity and is heavily damaged as a result. Many URMs in Memphis are damaged and contribute to the large number of URM damage cases. Approximately 25% of all URMs in the State of Tennessee are at least moderately damaged, while only 14% of mobile homes and 10% of wood frame buildings reach that same damage state. Nearly 50,000 URMs, 167,000 wood frame buildings and 37,000 mobile homes are at least moderately damaged in Tennessee, as shown in Table 56. This is the most building damage experienced by any state in the NMSZ region.

Damage and functional losses to essential facilities substantially impact the ability to provide emergency services immediately after the earthquake. Table 57 shows that eight hospitals are completely damaged by the NMSZ event and nearly 50 are not operational the day after the earthquake. Of the 2,309 schools in Tennessee, 635 are not functioning the day after the earthquake and all are located in the critical counties. A total of nearly 300 fire stations and 150 police stations are also not operational. These massive functional losses indicate that nearly all essential facilities in Shelby, Tipton, Lauderdale, Dyer, Lake, Obion, Fayette, Haywood, Crockett, Gibson, Weakley, Hardeman, Madison, McNairy, Chester, Henderson, Carroll, Henry, Hardin, Decatur, and Benton Counties are not functioning. These 21 counties comprise the entire western portion of Tennessee, indicating that a large portion of the state will be without emergency services and medical care immediately after the earthquake.

Table 57: NMSZ Event Essential Facilities Damage for the State of Tennessee[26]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	180	43	8	132
Schools	2,309	602	404	1,674
EOCs	0	0	0	0
Police Stations	423	124	78	289
Fire Stations	1,110	256	117	815

Transportation lifelines are also severely impacted by a NMSZ event and limit mobility into and out of western Tennessee in the aftermath of the earthquake. Nearly 900 bridges are at least moderately damaged, 330 completely damaged, and over 875 not functioning in the critical counties. Even if roads are passable, bridges are estimated to be damaged and will prevent displaced residents from leaving and response teams from entering western Tennessee. Railway facilities are also damaged, with 54 facilities experiencing at least moderate damage and over 50 not functioning the day after the event. Furthermore, 71 ports and 37 airports are non-operational immediately after the earthquake. The

[26] See footnote (3).

majority of these facilities are in Shelby, Tipton, Lauderdale, Dyer, Haywood, Crockett, Obion, Weakley and Gibson Counties in western Tennessee.

Table 58: NMSZ Event Highway Bridge Damage for the State of Tennessee[27]

Highway Bridge Damage Assessments				
	Total No. Of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
37 Critical Counties	3,815	877	330	2,937
Remaining Counties	3,400	1	0	3,400
Total State	7,215	878	330	6,337

The intense shaking from the southwest segment rupture affects the performance of utility lifelines significantly. Communication facilities, as illustrated in Table 59, indicate that nearly 3,500 structures are at least moderately damaged and nearly 2,000 are not functioning the day after the earthquake. With so many communication facilities down, it will be difficult to coordinate response efforts and determine which areas are heavily damaged and in need of assistance. Of the 153 electric power facilities in the 37 critical counties, 92 are not functioning the day after the earthquake. Half the oil facilities in the critical counties are shut down at day 1 (32 of 65) and nearly 500 of the 750 waste water facilities in the critical counties are not operating. This indicates that nearly all utility services in western Tennessee are moderately to substantially reduced for the first few days after the earthquake.

The lack of utility service is evident in Table 60. Of the 2.2 million households in the State of Tennessee, nearly 450,000 are without potable water the day after the event. This equates to approximately 20% of all households in the State of Tennessee. Over 425,000 households are without power at this time as well. After one week, nearly 300,000 households will have their electricity restored though more than 400,000 households, all in western Tennessee, are still without water. With more than 350,000 households without potable water for a month or more, many will leave their homes and many may seek public shelter.

For more information on direct damage and functional losses in the State of Tennessee, please refer to Appendix V for detailed assessment results and to Appendix VIII for damage and functionality maps.

[27] See footnote (3).

Table 59: NMSZ Event Communication Facilities Damage for the State of Tennessee[28]

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
37 Critical Counties	6,969	3,468	48	5,018
Remaining Counties	9,161	0	0	9,161
Total State	16,130	3,468	48	14,179

Table 60: NMSZ Event Utility Service Interruptions for the State of Tennessee

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	2,232,905	446,891	433,647	408,112	360,553	164,750
Electric Power		426,573	296,249	146,276	37,717	508

Regional Direct Damage & Functionality

Each of the ten earthquake impact assessments completed in this investigation is based on a different scenario event. Eight scenarios employ a NMSZ hazard event, one employs a WVSZ hazard event and the last scenario utilizes an ETSZ hazard event. Since each scenario is based on a different hazard, it is unrealistic to add damage estimates together for a regional damage total. Even the NMSZ scenarios employ events on differing fault segments and fault lines, meaning east or west fault lines in the New Madrid Seismic Zone. Though damage and functionality estimates should not be added for a region, total general observations of regional impacts can be made.

Building damage in all states, for all scenarios, indicate that residential buildings incur more damage than any other building use group/occupancy. In addition, wood frame structures are the most prevalent building type in the NMSZ and comprise a large portion of all building damage. Unreinforced masonry buildings comprise a much smaller portion of the regional building inventory, though damage estimates show a much higher percentage of these structures are damaged from moderate and severe shaking. The Tennessee earthquake impact assessment alone shows nearly 50,000 at least moderately damaged URMs, so it is reasonable to suggest that over 100,000 URMs could be damaged from a rupture of the southwest extension and several hundred thousand URMs could be damaged in the eight states if successive ruptures of the three segments occur, as in the 1811-1812 series of earthquakes.

Estimates of transportation damage and functionality indicate that counties nearest the source of seismic activity are heavily damaged and do not function in the days and weeks after the earthquake. Several hundred highway bridges near the source of seismic activity will make travel in counties near the source fault very difficult. Many airports and ports

[28] See footnote (3).

will not be operational making it more difficult to get supplies and rescue teams into the most heavily damaged areas.

Utility lifelines show substantial damage, particularly to communication facilities. The improved communication facilities inventories for each state include thousands or tens of thousands of facilities in some states. The rupture of a single segment could damage 10,000 communication facilities, some of which service cell phones, severely reducing communication capabilities, even wireless communication. Electric power facilities also show hundreds of cases of damage and exhibit severely reduced functionality in the critical counties near the fault segments. The same is true of waste water facilities, as they have reduced functionality in the critical counties. Reduced functionality and extensive pipeline damage near the faults leads to hundreds of thousands of households with potable water and electricity immediately after the event. With nearly 450,000 households without potable water in Tennessee alone, a southwest segment event could cut off service for 750,000 households, or more, immediately after the event. Similar estimates of service outages for electricity may occur as well.

Comparison with Other Published Studies

There are few earthquake impact assessments to compare with as the NMSZ is a largely unstudied region. In recent years, however, at least one regionally comprehensive impact assessment has been completed. The Central U.S. Earthquake Consortium (CUSEC) completed scenarios[29] for each NMSZ state using the southwest segment ground motion produced by the USGS, referred to earlier in this report. The following discussion compares the results of this study with the results obtained by CUSEC. Each study utilized various impact assessment parameters, including the location of the rupture within the fault boundaries, liquefaction susceptibility, and seismic design level, among others. Many damage estimates are based on the HAZUS-MH MR2 methodology of averaging damage at the county level, though there are other methods of determining damage. Another common method of identifying levels of damage is highlighted in Appendix V and is compared with the method of averaging damage at the county level. Finally, all CUSEC analyses included only a portion of the counties in the state scenarios. The counties identified in this study as critical counties correspond to the counties in the CUSEC study. As a result all comparisons in this section are for the critical counties only.

The State of Tennessee shows some of the greatest damage estimates of all the states in this investigation. Herein, nearly 82,000 buildings are expected to be completely damaged, though the CUSEC study predicts over 115,000 buildings in that same damage state. Estimates from CUSEC indicate that 67,000 buildings are moderately damaged while this investigation predicts over 131,000 moderately damaged buildings. This difference is likely due to the different liquefaction susceptibility maps used in each study. The CUSEC study utilized a liquefaction map with very high susceptibilities in Tennessee, leading to thousands more completely damaged buildings, as opposed to the

[29] The study completed by CUSEC is also known as the SONS 07 study due to the conference where it was first presented.

less severe liquefaction susceptibility in this study that leads to fewer completely damaged buildings and more moderately damaged buildings.

Utility lifelines frequently exhibit more damage and greatest services losses in the CUSEC study than in this study. The day after the earthquake, CUSEC estimates that nearly 534,000 households are without potable water while this investigation shows 446,000 without water. In addition, the CUSEC study reports more damaged facilities than this study. Again, this is likely due to the difference in liquefaction susceptibility data used.

The State of Missouri, which utilized the central extension event in this investigation, reports much greater damage estimates than the CUSEC study. This investigation shows over 83,000 at least moderately damaged buildings while CUSEC predicts nearly 53,000 buildings. Utility lifelines also show substantially greater damage in this investigation with over 20,000 potable water pipeline breaks, while CUSEC reports only 17,000 breaks. Over 100,000 households are expected to be without power the day after the earthquake in this investigation, while CUSEC shows only 40,000 households without power at the same post-earthquake time period.

The northernmost states in the NMSZ experience substantially more damage and service loss in this investigation, where the closest fault rupture is used in the impact assessments. In the State of Illinois, roughly 17,000 buildings are expected to incur complete damage based on the results of this investigation. The CUSEC study reports only 4,300 cases of complete damage. In addition, CUSEC reports nearly 16,000 at least moderately damaged buildings, which is far less than the 43,000 estimated in this study. This is due to the different scenario events employed in each investigation. Waste water facilities damage is not only impacted by the scenario event, but also by the vastly improved inventory. Of the 2,221 waste water facilities in the State of Illinois, over 640 are at least moderately damaged, according to this study. In contrast, the CUSEC study shows only 300 waste water facilities in Illinois and of those only 18 incur at least moderate damage.

In addition, a study was completed for the Illinois Emergency Management Agency (IEMA) for a major NMSZ event in the State of Illinois. Different ground shaking was used in this scenario, generating different results from those presented in this report. The IEMA Study shows that approximately 19,000 buildings are completely damaged, with roughly 75,000 buildings experiencing at least moderate damage. Conversely, this report shows nearly 17,000 completely damaged buildings and roughly 30,000 at least moderately damaged buildings. This difference is likely due to the difference in ground shaking and liquefaction susceptibility used in the IEMA study. This reports shows over 250 non-operational schools, while the IEMA study shows more than 320 non-operational schools the day after the earthquake. Conversely, this report indicates more highway bridge damage than the IEMA study. This report estimates over 250 at least moderately damaged bridges, even though the IEMA study shows only 150 in that same damage state. Finally, utility damage estimates differ greatly for some inventory items. This vast difference is likely due to the increased number of facilities in this study which are not present in the IEMA study. The IEMA study includes 153 electric power facilities

and 518 communication facilities of which three and 17 facilities experience at least moderate damage, respectively. This report includes nearly 2,200 electric power facilities and nearly 35,000 communication facilities and those facilities experience roughly 60 and 1,450 cases of at least moderate damage, respectively. The IEMA study and this report show different results, though both represent plausible earthquakes and corresponding damage to the State of Illinois. For more information on the IEMA study, please refer to Mid-America Earthquake Center (2007).

There are numerous parameters that affect the results of earthquake impact assessments, and as a result input variables must be carefully and accurately determined to obtain the best possible results. For more information on the comparison of this study with the CUSEC study, please refer to Appendix IX.

Social Impact and Direct Economic Loss

This section provides social impacts and direct economic losses for the ten scenarios completed in this phase of the New Madrid Seismic Zone Catastrophic Event Planning project. Induced damage is also included in this section and is quantified by various types of debris resulting from infrastructure damage. Social impacts include displaced residents, temporary shelter population, various food, medical and housing requirements for sheltered populations and casualties. Lastly, direct economic losses include estimates of building, transportation and utility losses plus building loss ratios. As with the earthquake impact assessment results, social impact and economic losses are presented by scenario. At the conclusion of this section is a series of maps illustrating building loss ratios for each scenario. For more information on social impacts and economic losses, please refer to Appendix VI.

State-Level Social Impact & Economic Loss

Alabama New Madrid Seismic Zone Scenario

Damage to infrastructure generates 112,000 tons of debris, which is the only form of induced damage provided in this investigation. Debris estimates are divided into two categories: steel and concrete debris and wood, masonry and building contents. This differentiation of debris is based on the type of equipment required to clear the debris. Steel and concrete require heavy lifting equipment while wood, bricks and building contents require much lighter and smaller equipment. The NMSZ scenario in Alabama generates 25,000 tons of steel and concrete debris while the remaining 87,000 tons is attributed to wood, bricks and building contents.

There are very few people displaced by the NMSZ event in the southwest segment. Table 61 details both displaced and shelter-seeking populations. Of the 4.4 million people in Alabama only 27 are displaced with the majority of those people residing in the 12 critical counties. Only five people seek temporary shelter and it requires 2,400 square feet

of space to house these people with 300 square feet reserved for sleeping. This sheltered population also requires beds, meals and water while they are in the temporary shelter. It is also estimated that there will be 17 cases of chronic health conditions within the displaced population. More detailed estimates of these needs are detailed in Appendix VI.

Table 61: NMSZ Event Shelter Requirements for the State of Alabama

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
12 Critical Counties	624, 368	24	5
Remaining Counties	3,822,732	3	0
Total State	4,447,100	27	5

Table 62: NMSZ Event Casualties for the State of Alabama

Worst Case Casualties (5:00 PM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
12 Critical Counties	29	3	1	0	32
Other Remaining Counties	39	6	8	2	56
Total State	68	9	9	2	88

Numerous casualties occur due to this event, though most are minor injuries. Of the 88 total casualties, 68 are minor injuries not requiring hospitalization. Two fatalities are expected and these do not occur in the critical counties. Of the three times of day considered in the social impact assessment, an event at 5:00 PM generates the greatest number of casualties, as shown in Table 62.

Direct economic losses are determined for buildings, transportation lifelines and utility lifelines. Utility losses account for over 50% of all direct economic loses. Table 63 illustrates that building losses and transportation losses contribute less, with 38% and 9%, respectively. Total direct economic losses are approximately $1 billion which is roughly 0.2% of all assets in the State of Alabama. Additionally, building loss ratios for the State of Alabama shown in Figure 19 at the conclusion of this section illustrate loss ratios for the NMSZ scenario. Ratios are less than 5% of total assets in any given census tract and are spread randomly across the state. This is likely due to the low levels of ground shaking and minor damage that is possible throughout the state. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 63: NMSZ Event Total Direct Economic Loss for the State of Alabama

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$269,580,000,000	$403,930,000
Transportation	$108,231,000,000	$95,700,000
Utility	$182,908,800,000	$568,770,000
Total	**$559,819,800,000**	**$1,068,400,000**

Alabama East Tennessee Seismic Zone Scenario

The ETSZ scenario generates 146,000 tons of debris in the State of Alabama. The majority of the debris, 85,000 tons, is comprised of brick, wood and building contents. The remaining 61,000 tons of debris is attributed to concrete and steel. The higher levels of shaking from the ETSZ event result in far more displaced people than the NMSZ scenario. All 1,625 displaced people reside in the 13 critical counties in eastern Alabama. Roughly 450 people will seek temporary shelter, as shown in Table 64. Over 200,000 square feet of space are required to house the shelter-seeking population and nearly 6,200 meals ready to eat (MREs) are needed to feed the sheltered population in the first week after the event.

Table 64: ETSZ Event Shelter Requirements for the State of Alabama

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
13 Critical Counties	1,751,879	1,625	440
Remaining Counties	2,695,221	0	0
Total State	4,447,100	1,625	440

Casualty estimates show that an event at 2:00 AM generates the most casualties. Table 65 shows that a total of 193 casualties are expected from the ETSZ event. All but one casualty occurs in the critical counties, with 80% of all casualties being minor injuries. Four fatalities are expected from this event as well as three serious injuries requiring immediate medical attention. The ETSZ scenario generates more than twice as many casualties as the NMSZ scenario.

Table 65: ETSZ Event Casualties for the State of Alabama

Worst Case Casualties (2:00 AM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
13 Critical Counties	153	32	3	4	192
Other Remaining Counties	1	0	0	0	1
Total State	154	32	3	4	193

The ETSZ shows much fewer economic losses than the NMSZ event. In this scenario, buildings represent the largest portion of the total direct economic losses, at nearly 60% of all losses. Utilities show a much lower percentage at 36%, with transportation losses making up the remainder. Direct economic losses total nearly $700 million, as shown in Table 66. Building loss ratios are illustrated in Figure 20 at the conclusion of this section. The maximum loss ratio occurs near the epicenter and it is less than 10% of all building value in that area. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 66: ETSZ Event Total Direct Economic Losses for the State of Alabama

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$269,580,000,000	$404,030,000
Transportation	$108,231,020,000	$39,980,000
Utility	$182,908,800,000	$254,400,000
Total	**$560,719,820,000**	**$698,410,000**

Arkansas New Madrid Seismic Zone Scenario

The intense shaking in the State of Arkansas from the southwest segment rupture generates 7,000,000 tons of debris. Approximately 3,400,000 tons are attributed to wood, bricks and building contents while the remaining debris, 3,600,000 tons, is steel and concrete. When a 25-ton capacity truck is used for debris removal, a total of 280,000 truckloads are required to remove all the debris.

The structural damage in Arkansas leaves nearly 127,000 people displaced. Of the 1.3 million people that reside in the 34 critical counties, approximately 10% cannot stay in their homes. Roughly 30% of the displaced population seeks temporary public shelter. This equates to over 37,000 people, as shown in Table 67. This estimate does not include those displaced due to a lack of utility services. Estimates shown here may increase significantly if those displaced from lack of utility services are included.

The southwest rupture in the State of Arkansas causes approximately 14,000 casualties which are illustrated in Table 68. Of the three times of day considered, an event at 2:00 AM generates the greatest number of casualties. Nearly 75% of all casualties are minor injuries (Level 1), though nearly 600 fatalities are expected. Though not shown here all casualties occur in the critical counties.

Table 67: NMSZ Event Shelter Requirements for the State of Arkansas

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
34 Critical Counties	1,330,090	126,987	37,244
Remaining Counties	1,334,739	1	0
Total State	2,664,829	126,988	37,244

Table 68: NMSZ Event Casualties for the State of Arkansas

Worst Case Casualties (2:00 AM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
34 Critical Counties	10,275	2,796	306	574	13,951
Remaining Counties	21	1	4	0	26
State Total	10,296	2,797	310	574	13,977

Direct economic losses for the State of Arkansas total approximately $19 billion. Table 69 shows the distribution of economic losses by major inventory group. Regional buildings account for the majority of losses at $12.6 billion in building losses. This is approximately two-thirds of all direct economic losses. Utility and transportation losses comprise the remaining losses, representing roughly 20% and 10% of the total loss, respectively. Additionally, building loss ratios are shown in Figure 21 for the State of Arkansas. The greatest loss ratios are between 50% and 83% of total building assets lost, and this occurs in portions of Mississippi, Poinsett, Craighead and Crittenden Counties. Many other counties in northeast Arkansas also experience significant loss ratios of between 25% and 50%. Loss ratios throughout the remainder of the state are typically less than 10%, which is far less severe than the counties nearest the rupture zone. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 69: NMSZ Event Total Direct Economic Losses for the State of Arkansas

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$157,602,000,000	$12,597,230,000
Transportation	$67,940,310,000	$2,154,660,000
Utility	$47,658,900,000	$4,126,730,000
Total	**$273,201,210,000**	**$18,878,620,000**

Illinois New Madrid Seismic Zone Scenario

The damage incurred by buildings in the State of Illinois generates roughly 2,570,000 tons of debris. Bricks, wood and building contents account for 1,400,000 tons while the remaining 1,170,000 tons is attributed to steel and concrete. It requires approximately 103,000 truckloads using 25-ton capacity trucks to remove all the debris generated by this event.

Table 70: NMSZ Event Shelter Requirements for the State of Illinois

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
40 Critical Counties	1,347,307	51,426	14,716
Remaining Counties	11,071,996	43	10
Total State	12,419,293	51,469	14,726

The extensive damage to buildings in southern Illinois displaces tens of thousands of people, as shown in Table 70. Nearly 51,500 people are displaced with most residing in the critical counties. Approximately 15,000 people seek temporary shelter, and the remainder of the displaced population likely seeks shelter with family or friends outside the region that is critically impacted. Over seven million square feet of space is required

to house the shelter-seeking population. In addition, over 160,000 gallons of water and nearly 325,000 MREs are required to feed this population for one week.

The northeast segment rupture causes over 6,200 casualties in the State of Illinois. Over 98% of those casualties occur in the critical counties, though over 100 minor injuries occur outside this region. As illustrated in Table 71, 276 fatalities are expected and roughly 1,400 people will require medical attention (Levels 2 & 3). However, many of the casualties, around 70% are minor (Level 1) and will not require advanced medical care.

Table 71: NMSZ Event Casualties for the State of Illinois

Worst Case Casualties (2:00 AM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
40 Critical Counties	4,478	1,236	146	276	6,136
Other Remaining Counties	109	5	0	0	114
Total State	4,587	1,241	146	276	6,250

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Direct economic losses in the State of Illinois are among some of the greatest losses incurred by any state in this investigation. Table 72 shows that total direct economic losses exceed $34 billion, with nearly 80% of that amount attributed to utility losses alone. This is likely due to the large number of utility facilities in the state's inventory, particularly communication and electric power facilities. Building losses and transportation losses comprise much smaller portions of the total loss, at 15% and 5%, respectively. Building loss ratios for the State of Illinois are shown in Figure 22 and help illustrate the impact on specific portions of southern Illinois. Portions of Alexander, Massac, and Union Counties experience the greatest loss ratios of 40% or more. Numerous other counties in southern Illinois show loss ratios greater than 10%, which is also critical. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 72: NMSZ Event Total Direct Economic Losses for the State of Illinois

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$837,682,000,000	$5,451,220,000
Transportation	$161,097,310,000	$1,883,180,000
Utility	$1,001,675,900,000	$26,779,240,000
Total	**$2,000,455,210,000**	**$34,113,640,000**

Indiana New Madrid Seismic Zone Scenario

The northeast segment rupture generates 282,000 tons of debris in the State of Indiana as a result of damage to infrastructure. Brick, wood and building contents account for 73%, or 205,000 tons of debris. Steel and concrete comprise the remaining 77,000 tons. Damage to residential structures displaces roughly 60 people with 14 seeking temporary

public shelter. Table 73 shows that most of the displaced individuals reside in the critical counties. The same pertains to the majority of the shelter-seeking population.

Of the three times of day considered in the analysis of casualties, an event at 5PM generates the greatest number of casualties. Table 74 illustrates the various types of casualties expected and it is evident most of the injuries, approximately 75%, are minor (Level 1) casualties. Only three fatalities (Level 4) are expected. Additionally, less than 60% of all casualties are expected to occur within the 11 critical counties, indicating that shaking and damage are not confined to this portion of southwestern Indiana.

Table 73: NMSZ Event Shelter Requirements for the State of Indiana

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
11 Critical Counties	480,752	52	13
Remaining Counties	5,599,733	6	1
Total State	6,080,485	58	14

Table 74: NMSZ Event Casualties for the State of Indiana

Worst Case Casualties (5:00 PM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
11 Critical Counties	57	12	12	2	83
Other Remaining Counties	53	4	4	1	62
Total State	110	16	16	3	145

Direct economic losses for the State of Indiana are minor in comparison with the total value of inventory in state. Approximately $1.4 billion is lost as the result of damage to buildings, transportation and utility systems. This is roughly 0.2% of the total value of assets in Indiana. Table 75 shows that buildings and utility systems contribute roughly the same value of loss, while transportation lifelines account for far less. Additionally, building loss ratios for the NMSZ scenario in Indiana are illustrated in Figure 23. All loss ratios are less than 2% and are very small in comparison with other loss ratios near the source of rupture. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 75: NMSZ Event Total Direct Economic Losses for the State of Indiana

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$380,969,000,000	$612,750,000
Transportation	$107,793,100,000	$158,100,000
Utility	$142,908,890,000	$647,880,000
Total	**$631,670,990,000**	**$1,418,730,000**

Indiana Wabash Valley Seismic Zone Scenario

The WVSZ event in the State of Indiana generates approximately 1.8 million tons of debris as a result of structural damage. Nearly 830,000 tons of debris is attributed to bricks, wood and other building contents. The remaining 930,000 tons of debris are comprised of steel and concrete. A total of 70,000 truckloads are required to remove all the debris when a 25-ton truck is used.

The more intense shaking in southwestern Indiana due to the WVSZ event displaces far more people than the NMSZ event. As shown in Table 76, nearly 28,000 people are displaced with a majority of those people residing in the critical counties. Approximately 7,000 people that are displaced will seek temporary public shelter. Nearly 3.4 million square feet of space is required to house this shelter-seeking population. In addition, 98,000 MREs and 246,000 gallons of water are required to feed this population.

Table 76: WVSZ Event Shelter Requirements for the State of Indiana

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
11 Critical Counties	480,752	26,721	6,815
Remaining Counties	5,599,733	899	212
Total State	6,080,485	27,620	7,027

Table 77: WVSZ Event Casualties for the State of Indiana

Worst Case Casualties (2:00 AM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
11 Critical Counties	2,012	572	64	118	2,766
Other Remaining Counties	193	24	1	3	221
Total State	2,205	596	65	121	2,987

Casualty estimates are also greater with this WVSZ scenario than with the NMSZ scenario. This difference is attributed to the higher level of damage to buildings—particularly residential buildings. The greatest number of casualties occurs at 2:00 AM as shown in Table 77. Nearly 3,000 casualties are expected, with over 2,200 being minor injuries. Approximately 120 fatalities are expected as well. This equates to roughly 4% of all casualties. Nearly all casualties occur in the 11 critical counties, with only 7% occurring outside that region.

Total direct economic losses for the State of Indiana illustrate the greater economic impact of the WVSZ event. Direct economic losses total roughly $7.2 billion, with $3.9 billion attributed to building losses, as shown in Table 78. Utility and transportation losses comprise the remainder with 40% and 5% of total losses, respectively. In addition, loss ratios for the WVSZ in the State of Indiana are illustrated in Figure 24. Building loss ratios compare the value of building assets lost to that total value of buildings in a

specified region and are excellent indicators for the effort required to rebuild an area. The greatest loss ratios, between 15% and 27%, occur in Gibson and Knox Counties. The majority of Indiana, however, shows relatively low loss ratios, less than 2%. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 78: WVSZ Event Total Direct Economic Losses for the State of Indiana

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$380,969,000,000	$3,927,530,000
Transportation	$107,793,100,000	$385,100,000
Utility	$142,908,890,000	$2,936,550,000
Total	**$631,670,990,000**	**$7,249,180,000**

Kentucky New Madrid Seismic Zone Scenario

The thousands of damaged buildings in the State of Kentucky, particularly western Kentucky, generate a substantial amount of debris. A total of 4,000,000 tons of debris is produced with 2,100,000 tons attributed to steel and concrete. Brick, wood and building contents comprise the remaining 1,900,000 tons. Approximately 160,000 truckloads are required to remove the entirety of debris when a 25-ton truck is used.

The extensive damage to the critical counties leaves tens of thousands displaced, with thousands more displaced outside this region. Nearly 53,000, or over 65% of all displaced people, reside in the critical counties with another 25,000 displaced in central Kentucky. These estimates indicate that 2% of the entire population is displaced, though when considering the critical counties only, more than 8% of the population is displaced, which is a far more significant portion. Table 79 shows the distribution of the shelter-seeking population in and out of the 25 critical counties. Approximately 20,700 people seek public shelter and roughly 13,900 are in the critical counties alone. Nearly ten million square feet of space are required to house the entire displaced population. In addition, 1.2 million pounds of ice and 300,000 MREs are required to feed this group of people for one week.

Table 79: NMSZ Event Shelter Requirements for the State of Kentucky

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
25 Critical Counties	655,184	52,964	13,904
Remaining Counties	3,386,585	25,225	6,759
Total State	4,041,769	78,189	20,663

Damage to infrastructure leads to nearly 10,000 casualties throughout the state of Kentucky. Table 80 illustrates the various types of casualties estimated should the event occur at 2:00 PM. Approximately 6,800 minor injuries are expected (Level 1) while

nearly 600 fatalities are expected. Very few casualties, mostly injuries, are expected to occur outside the 25 critical counties.

The severity of damage to infrastructure, especially in western Kentucky, leads to substantial direct economic losses. The majority of losses, roughly 75% of all direct losses, are attributed to utility lifelines. This is due to the significantly improved inventory and thousands of new facilities. Buildings and transportation lifelines incur much smaller proportions of direct losses with roughly 20% and 3% of all direct loss, respectively. Kentucky is one of the few states in the NMSZ to incur this amount of direct economic loss.

Furthermore, building loss ratios are illustrated in Figure 25 at the conclusion of this section. Several counties in western Kentucky show substantial loss ratios between 40% and 75%. These counties include Fulton, Hickman, Carlisle, Ballard, Graves, and McCracken Counties. Loss ratios as high as reported indicate that a majority of the building stock is lost and many buildings must be replaced completely or will require significant repairs are required. Portions of Graves, Marshall, Union, and Hopkins Counties also show loss ratios between 10% and 20% which are significant, but not as critical as those in the western counties near the rupture zone. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 80: NMSZ Event Casualties for the State of Kentucky

Worst Case Casualties (2:00 PM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
25 Critical Counties	6,722	2,051	318	593	9,684
Other Remaining Counties	49	5	1	0	56
Total State	6,771	2,056	319	593	9,740

Table 81: NMSZ Event Total Direct Economic Losses for the State of Kentucky

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$259,784,000,000	$9,442,940,000
Transportation	$128,035,860,000	$1,291,480,000
Utility	$797,983,900,000	$35,291,800,000
Total	**$1,185,803,760,000**	**$46,026,220,000**

Mississippi New Madrid Seismic Zone Scenario

Damage to infrastructure in Mississippi creates two million tons of debris. The majority of this debris, 1.2 million tons, is steel and concrete, while the remaining 0.8 tons is brick, wood and buildings contents. A total of 80,000 truckloads with a 25-ton capacity truck are required to remove all the debris generated by this southwest segment rupture.

Tens of thousands of people are forced to leave their homes due to structural damage. Approximately 21,000 people are displaced with nearly all of those people residing in the critical counties. Nearly 5,600 of those displaced seek public shelter, as shown in Table 82. To care for this sheltered population, 2.7 million square feet of space are required, with 334,000 square feet reserved just for sleeping. Nearly 40,000 gallons of water and 78,000 MREs are required to feed this population for the first week after the event.

Table 82: NMSZ Event Shelter Requirements for the State of Mississippi

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
25 Critical Counties	748,030	20,832	5,555
Remaining Counties	2,096,628	34	11
Total State	2,844,658	20,866	5,566

Structural damage to buildings and lifelines leads to nearly 4,000 casualties throughout the State of Mississippi. Over 70% of all casualties are minor injuries (Level 1) and 20% require immediate or delayed medical attention (Levels 3 & 2, respectively). Table 83 shows that only 200 fatalities are expected throughout the state.

The level of direct economic losses incurred by the State of Mississippi is less severe than the losses incurred by other states in the NMSZ, though this is expected due to the lower level of shaking throughout the majority of the State. Nearly 60% of all direct economic losses are attributed to utility lifelines. Buildings show a total loss of approximately $3.8 billion and transportation lifelines contribute significantly less with only 3% of all direct economic losses. This is likely due to the smaller set of inventory when compared to the total number of utility facilities and network components, for example.

Table 83: NMSZ Event Casualties for the State of Mississippi

Worst Case Casualties (2:00 PM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
25 Critical Counties	2,036	474	45	86	2,641
Other Remaining Counties	855	294	65	122	1,336
Total State	2,891	768	110	208	3,977

The greatest building loss ratios occur in portions of Tunica and Desoto counties in northwestern Mississippi. Ratios of 20% to 33% indicate that a significant portion of the building stock is damaged and require repair. Loss ratios less than 5% are more common throughout the majority of the state, however. Building loss ratios for the State of Mississippi are illustrated in Figure 26. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Table 84: NMSZ Event Total Direct Economic Losses for the State of Mississippi

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$131,314,000,000	$3,769,990,000
Transportation	$69,176,250,000	$279,730,000
Utility	$266,440,450,000	$5,441,930,000
Total	**$466,930,700,000**	**$9,491,650,000**

Missouri New Madrid Seismic Zone Scenario

The central segment event generates six million tons of debris in the State of Missouri. Steel and concrete buildings account for 3.1 millions tons of debris, while brick, wood and building contents comprise the remaining 2.9 million tons. A total of 240,000 truckloads with a 25-ton truck are required to remove all the debris created by this earthquake.

Missouri is one of the most catastrophically impacted states in the NMSZ zone with regard to social impacts and economic losses. As illustrated in Table 85, nearly 122,000 people are displaced, which is far more than any other scenario discussed previously. Nearly all displaced residents reside in the critical counties in southeastern Missouri. Approximately 36,700 people seek temporary public shelter after the NMSZ event. Substantial amounts of space are required to house all those displaced. Nearly 18 million square feet of space is required, while 1.3 million gallons of water and over 500,000 MREs are needed in the first week to care for the sheltered population.

Table 85: NMSZ Event Shelter Requirements for the State of Missouri

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
46 Critical Counties	3,043,805	121,927	36,702
Remaining Counties	2,551,406	2	2
Total State	5,595,211	121,929	36,704

Table 86: NMSZ Event Casualties for the State of Missouri

Worst Case Casualties (2:00 AM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
46 Critical Counties	11,267	3,177	401	760	15,605
Remaining Counties	33	1	0	0	34
Total State	11,300	3,178	401	760	15,639

The tens of thousands of damaged buildings cause nearly 16,000 casualties, with most occurring in the 46 critical counties. Well over 11,000 minor injuries are expected, though injuries requiring medical attention are far less than that. This equates to 3,600

people requiring delayed or immediate medical attention, which will be difficult when most hospitals in the critical counties are not operational. In addition, transportation lifelines may be damaged and routes to the functioning care facilities impassible. Table 86 shows nearly 800 expected fatalities, which is much higher than any other scenario estimate.

Despite the very high social impact estimates, direct economic losses are not as high other states. Nearly $39 billion in total direct economic loss is expected for the State of Missouri. Approximately 65% of all direct economic losses can be attributed to utility lifelines. Buildings account for $11.8 billion, or 30%, of all losses and transportation lifelines comprise the remaining 5%. These values are illustrated in Table 87.

Table 87: NMSZ Event Total Direct Economic Losses for the State of Missouri

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$334,877,000,000	$11,811,430,000
Transportation	$121,237,610,000	$1,772,590,000
Utility	$564,861,000,000	$25,138,310,000
Total	**$1,020,975,610,000**	**$38,722,330,000**

Building loss ratios also show the catastrophic level of damage in some areas of southeastern Missouri. Figure 27 illustrates the very high loss ratios in Pemiscot, Dunklin, New Madrid, and Stoddard Counties. Between 70% and 91% of building value is lost in these areas, indicating that a significant portion of those counties needs to be repaired or rebuilt after a NMSZ earthquake. Several other counties in southeast Missouri show loss ratios greater than 20% which is less critical, but still significant. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

Tennessee New Madrid Seismic Zone Scenario

The southwest segment rupture zones runs along the western edge of Tennessee, generating substantial damage and significant amounts of debris. Over 20 million tons of debris is expected with 8.8 million tons attributed to brick, wood and building contents. The remaining 11.9 million tons is comprised of steel and concrete. A total of 800,000 truckloads with 25-ton trucks are required to remove all the debris from this event.

Social impacts are more severe in the State of Tennessee than in any other state. Nearly 263,000 people are displaced, which is likely due to the major population center of Memphis, TN, incurring significant damage. Of the hundreds of thousands displaced, over 73,000 will seek public shelter. Table 88 details the sheltering estimates and shows that nearly all displaced people reside in the 37 critical counties in western Tennessee. It requires over 35 million square feet to house these 73,000 people. Additionally, over 500,000 gallons of water, four million pounds of ice and over one million MREs are required to feed this group of people in the first week alone.

Extensive structural damage leads to tens of thousands of casualties as detailed in Table 89. A total of 63,000 casualties are expected if the event occurs at 2:00 PM. If the event were to occur at other times of day, casualty estimates will be less than 63,000. Nearly 70% of all casualties are minor injuries, though nearly 4,100 fatalities are expected. Approximately 15,500 people require immediate or delayed medical attention (Level 3 & 2, respectively), though with many hospitals not functioning in the harder hit areas medical services will be scarce. Roughly 75% of all casualties occur in the 37 critical counties in western Tennessee, indicating that 17,000 casualties will occur outside this region. Medical facilities outside the critical counties are more likely to be operational immediately after the event and thus able to care of those that are injured. In addition, the operational facilities closest to the heavily damaged counties will likely need to care for victims evacuated from the critical counties in the first hours and days after the earthquake.

Table 88: NMSZ Event Shelter Requirements for the State of Tennessee

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
37 Critical Counties	2,699,993	262,907	73,293
Remaining Counties	2,989,290	2	0
Total State	5,689,283	262,909	73,293

Table 89: NMSZ Event Casualties for the State of Tennessee

Worst Case Casualties (2:00 PM)					
Severity Level	**Level 1 (Green)**	**Level 2 (Yellow)**	**Level 3 (Red)**	**Level 4 (Black)**	**Total**
37 Critical Counties	31,913	9,706	1,544	2,904	46,067
Other Remaining Counties	11,419	3,759	609	1,184	16,971
Total State	43,332	13,465	2,153	4,088	63,038

Direct economic losses in the State of Tennessee are the greatest of any state in the NMSZ. A total of $56.6 billion is lost in combined building, transportation and utility infrastructure value. Table 90 illustrates the losses in each of these three categories. Building losses are the greatest portion of total loss with $40.3 billion in losses, representing 70% of all losses. Utility and transportation lifelines contribute lesser proportions with 25% and 3% of all direct economic losses, respectively.

Table 90: NMSZ Event Total Direct Economic Losses for the State of Tennessee

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$329,827,000,000	$40,316,300,000
Transportation	$82,455,530,000	$1,746,230,000
Utility	$173,425,200,000	$14,576,340,000
Total	**$585,707,730,000**	**$56,638,870,000**

Building loss ratios for the State of Tennessee are illustrated in Figure 28. Though building losses are very high, the greatest loss ratios are confined to several small regions. Portions of Tipton and Crockett Counties show loss ratios of 40% to 62%, which is roughly half of all building value lost in those areas. Additionally, the City of Memphis shows loss ratios of 20% to 40% in some areas. This may be due to the large number of URMs in the city that are expected to incur sever damage. The majority of the rest of Tennessee shows much lesser loss ratios of 2% or less. For more information on social impacts and economic losses for this scenario, please refer to Appendix VI.

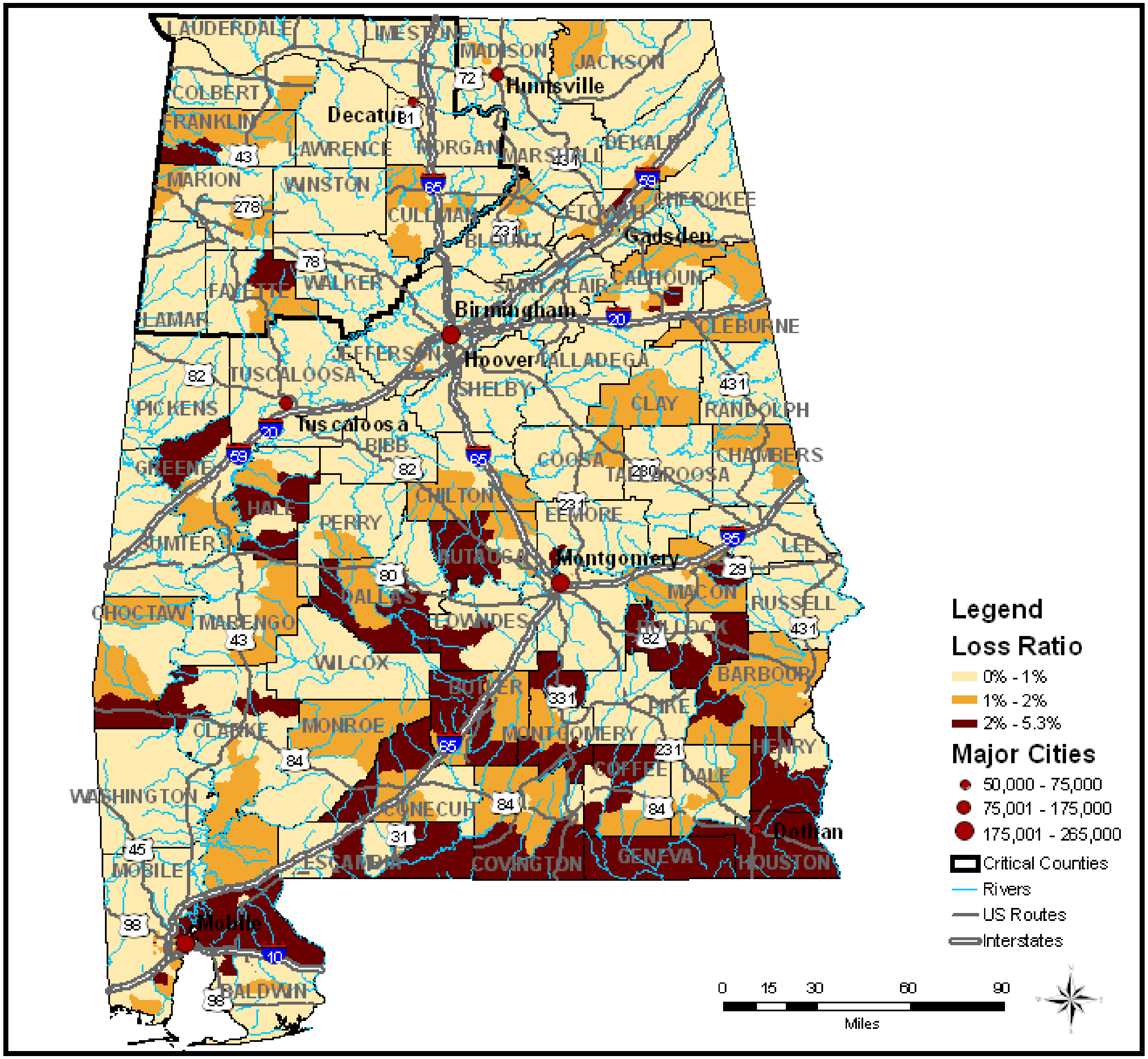

Figure 19: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Alabama

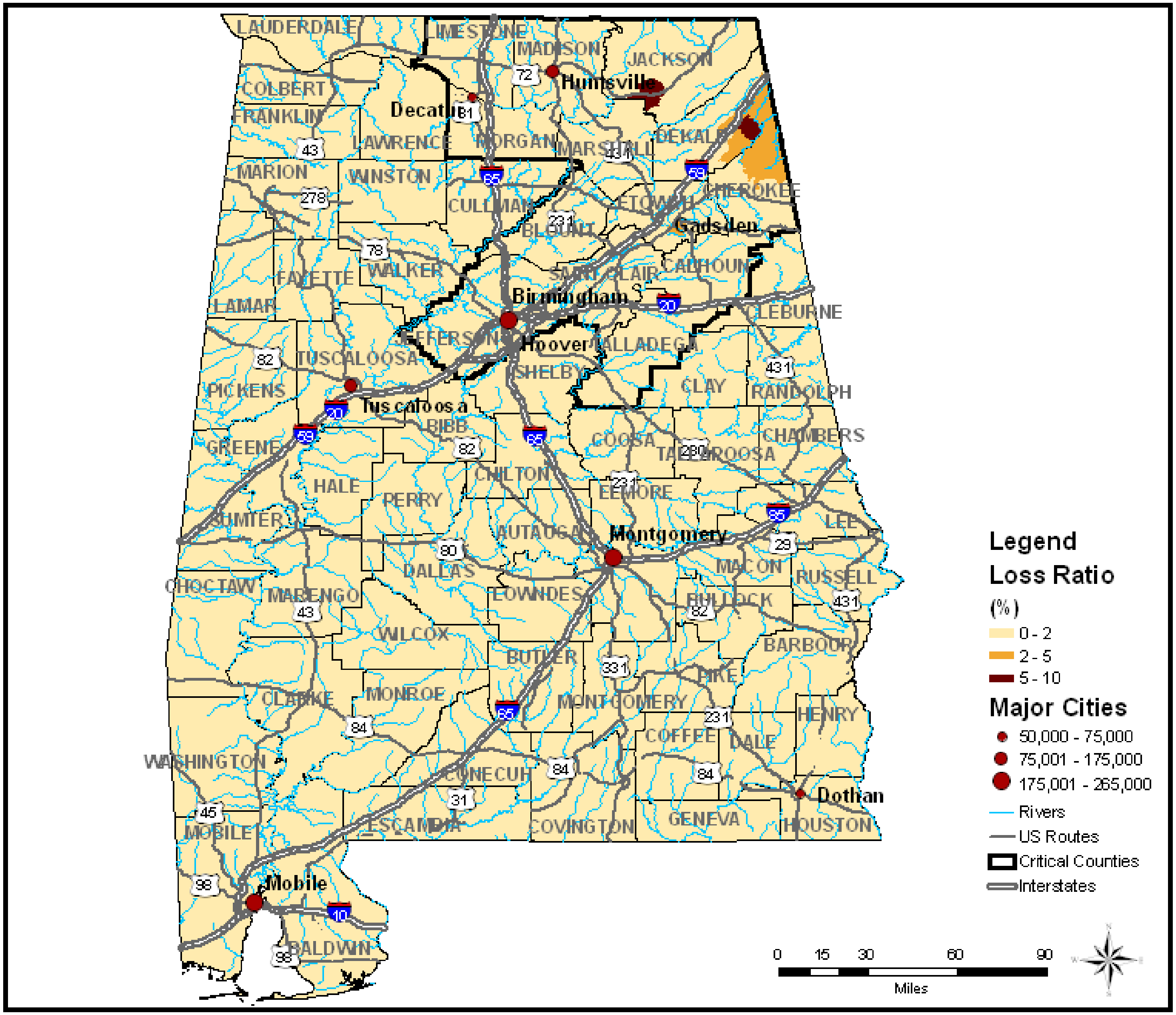

Figure 20: ETSZ Event Loss Ratio (% of Total Building Assets) for the State of Alabama

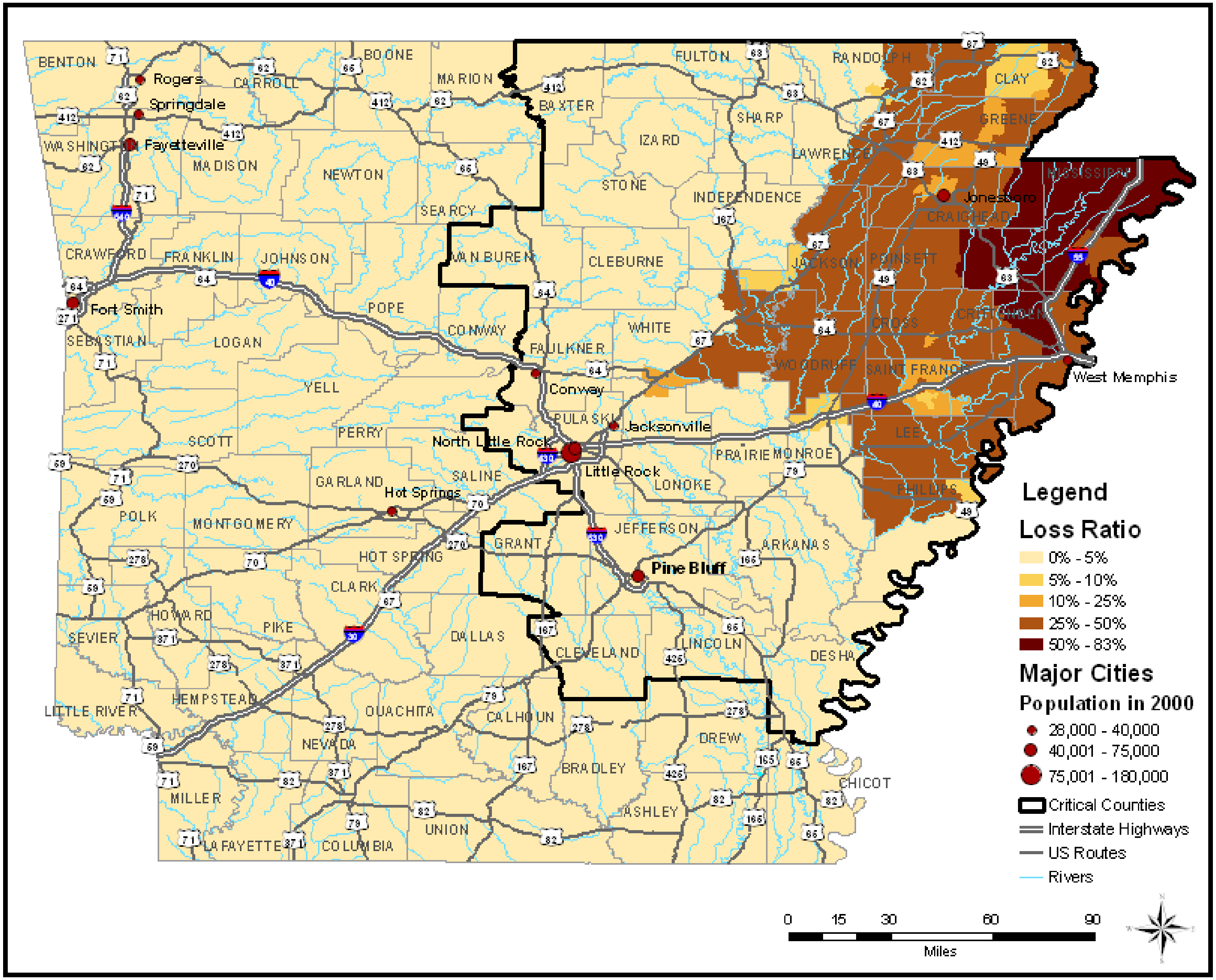

Figure 21: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Arkansas

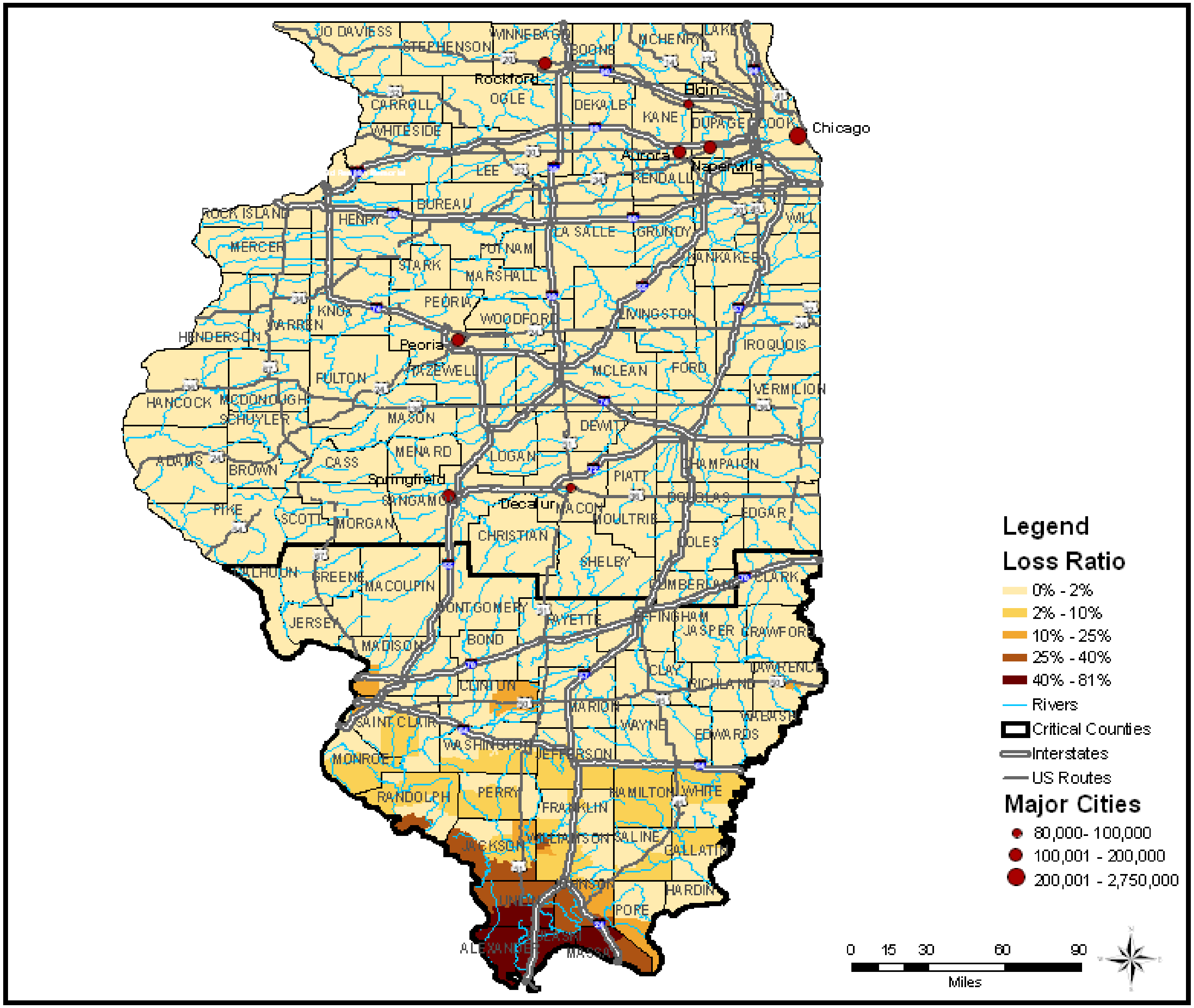

Figure 22: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Illinois

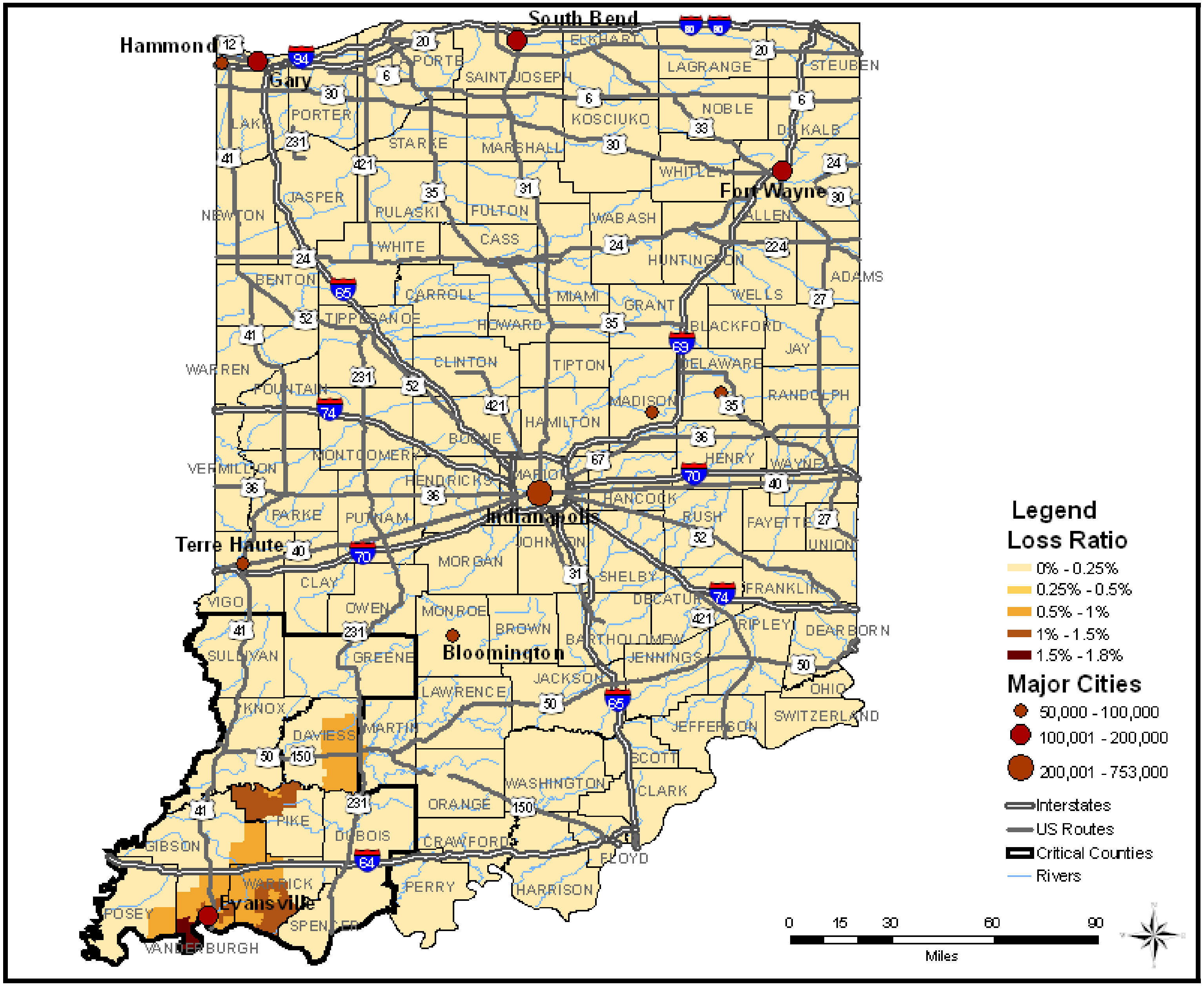

Figure 23: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Indiana

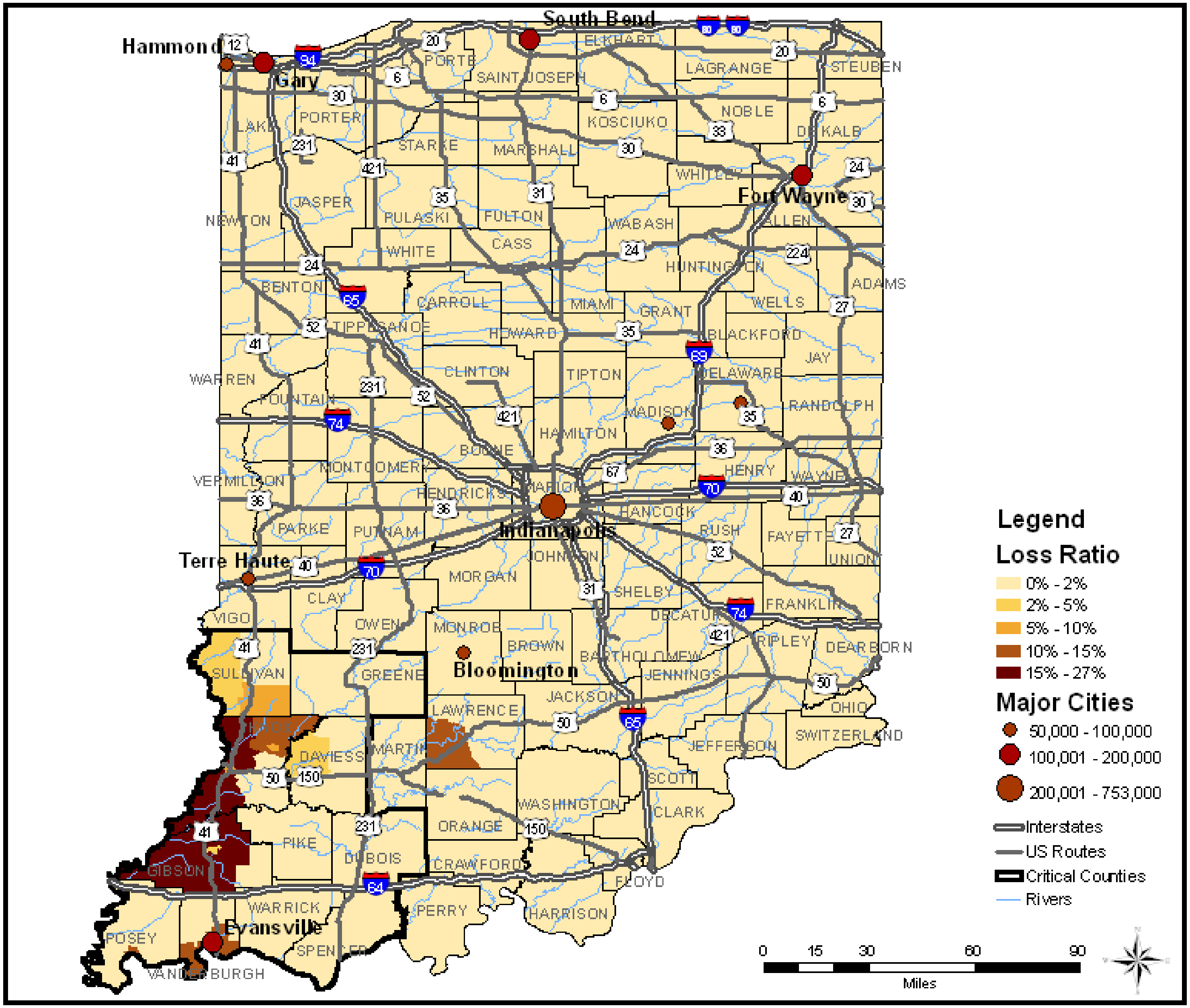

Figure 24: WVSZ Event Loss Ratio (% of Total Building Assets) for the State of Indiana

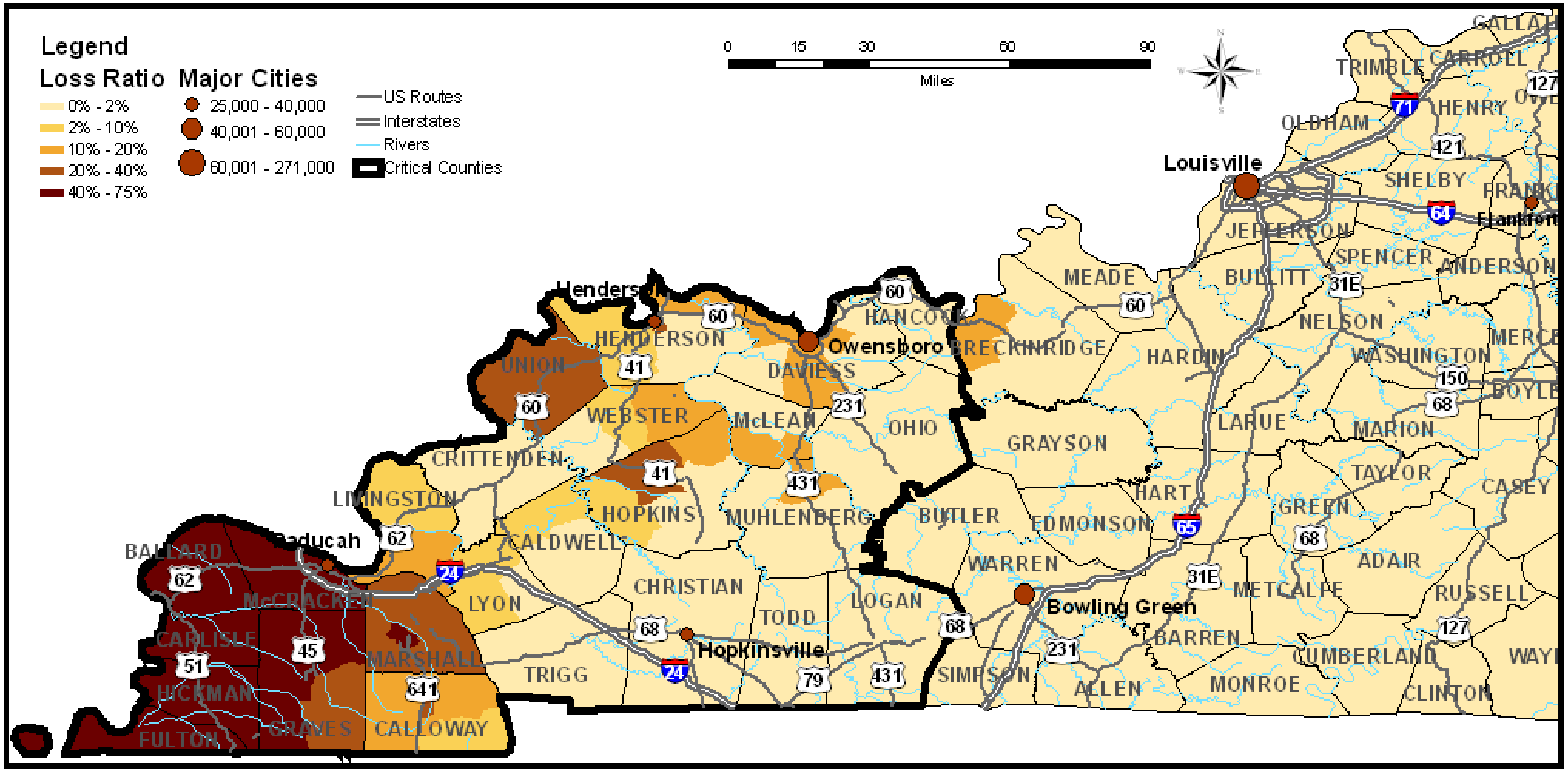

Figure 25: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Kentucky

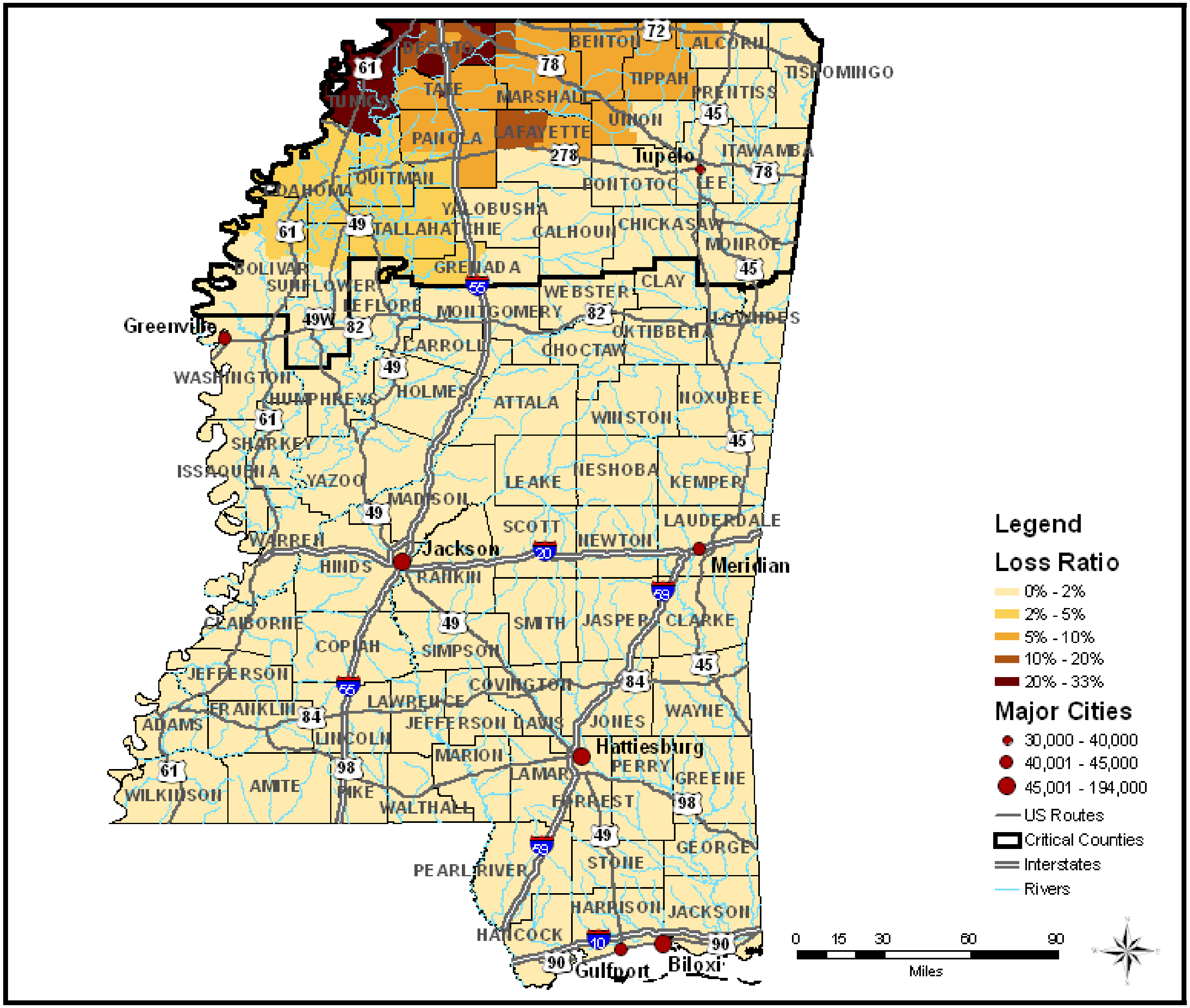

Figure 26: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Mississippi

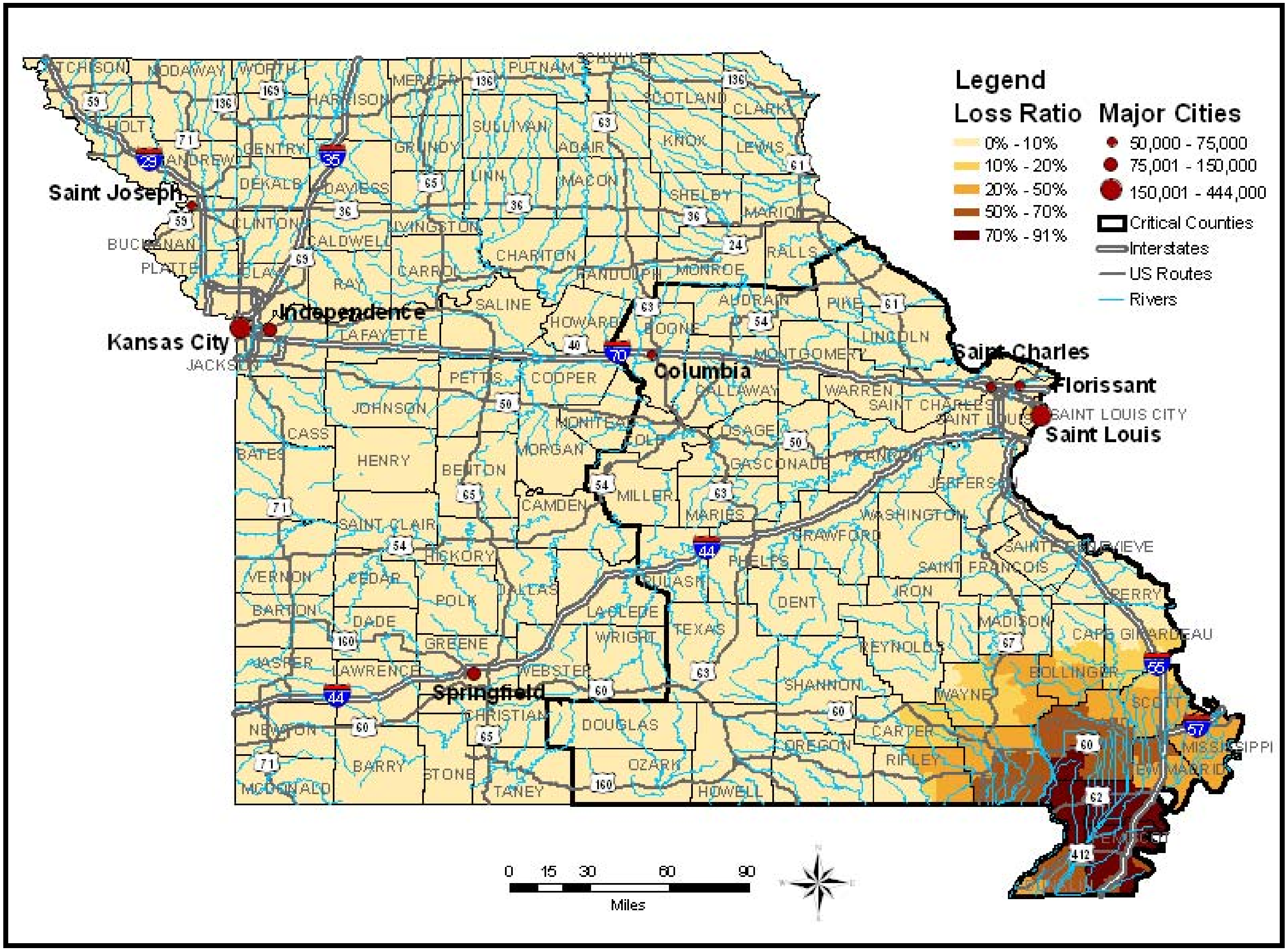

Figure 27: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Missouri

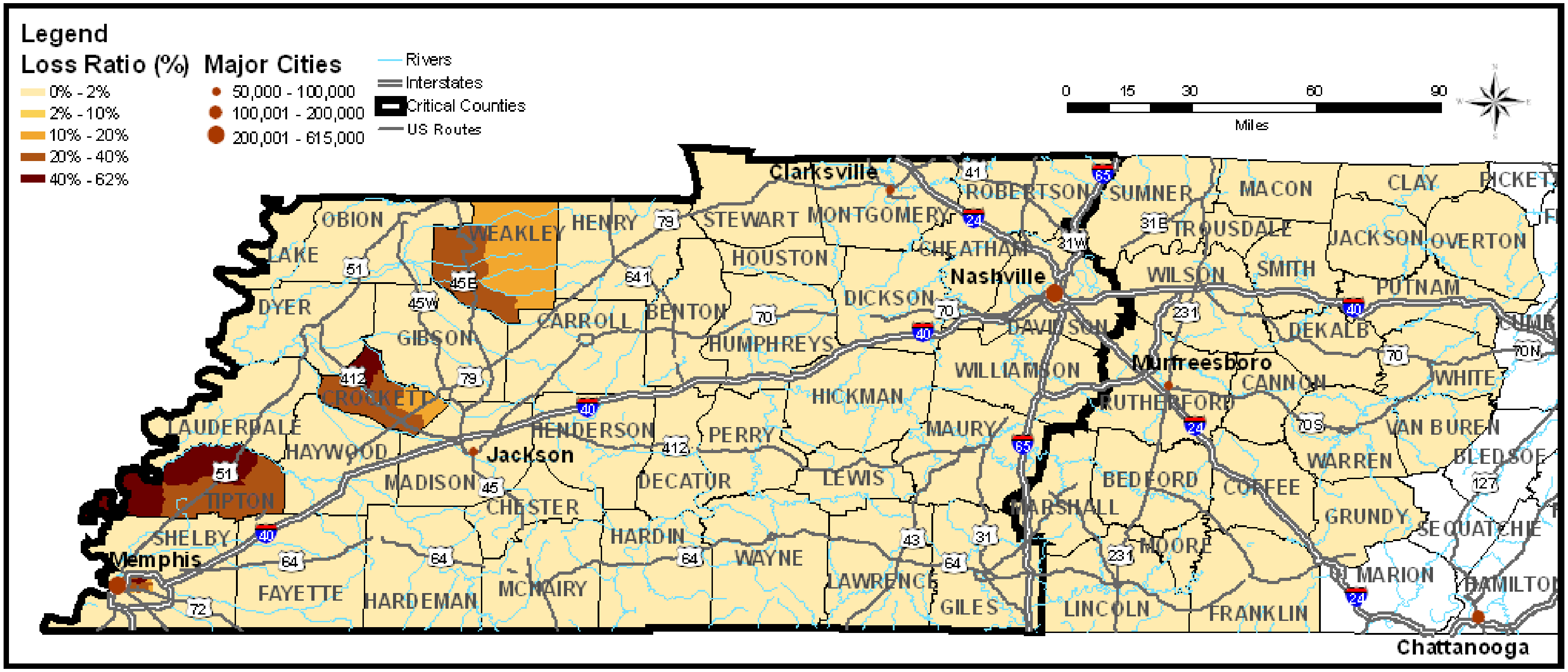

Figure 28: NMSZ Event Loss Ratio (% of Total Building Assets) for the State of Tennessee

Regional Social Impact and Economic Loss

As stated for the direct damage estimates, social losses and economic impacts should not be combined over all scenarios for regional totals. Since each scenario is based on a different hazard, adding impacts together will not reflect one regional scenario. It is possible, however, to discuss qualitatively the impact on this eight state region.

Some states are more likely than others to incur substantial casualties and economic loss based on their location in relation to the source of rupture. Southern states such as Alabama and southern Mississippi show very few casualties, if any, and minimal economic losses. As a result, these areas will be more likely to provide supporting services to heavily impacted areas after the earthquake. Such services may include sheltering displaced populations, providing medical services at functioning hospitals and providing staging areas for rescue and aid workers. The same is true for northern Illinois and most of Indiana. These states, or portions of states, see very few casualties or displaced residents. Such areas will be able to provide similar services to more northern areas that are heavily damaged from a NMSZ event. Should a WVSZ event occur, however, these areas are likely to experience substantial impacts and will require outside assistance.

Areas nearest the NMSZ are likely to see wide-spread and catastrophic social impacts and economic losses. Southeast Missouri, western Kentucky and Tennessee, northeast Arkansas and southern Illinois show the most significant social impacts. A southwest event affects the major population center of Memphis, TN, and leaves nearly 265,000 people displaced and over 63,000 people injured or killed. A southwest segment event could leave up to 500,000 people without homes and could injure 150,000 people across the entire NMSZ area. Up to 100,000 people may need temporary public shelter, which would require several million MREs for the first week alone. In addition, over one million gallons of water and as many as ten million pounds of ice may be needed for a NMSZ event. It is very likely that an event on the southwest segment will produce the greatest social impacts and thus present the largest requirements for food, water, ice, and shelter space.

Substantial losses in Tennessee, Kentucky, Arkansas, northwestern Mississippi and southeastern Missouri would likely generate over $100 billion in direct economic losses. A large portion of these losses would be due to utility lifeline losses with building losses contributing a significant portion as well. A northeast segment event, however, would impact southern Illinois as well as parts of Missouri and Kentucky. Economic losses caused by a northeast segment effect, while likely to be less than a southwest segment event, would result in total losses possibly reaching $75 billion in direct economic losses.

Comparison with Other Published Studies

As mentioned earlier, the earthquake impact assessment carried out by CUSEC provides the only regionally comprehensive study by which to compare results. The following

discussion compares the results of this study with those of the CUSEC study. It is also critical to note that the CUSEC study does not provide advanced social impact modeling, which details additional housing and medical requirements. New information that is only available in this study includes space requirements, number of beds, amount of food, water and ice needed, as well as estimates of medical assistance requirements for the displaced population. Since these impacts are not available in the CUSEC study they are not compared herein. Other estimates such as displaced population, casualties, debris and direct economic loss are compared in this section. In addition, the CUSEC study only includes those counties identified as critical counties in this study; thus, all comparisons are for the critical counties in each scenario only. It should also be noted that the displaced residences/households model and temporary shelter model were implemented incorrectly in the version of HAZUS-MH MR2 utilized in the CUSEC study. This investigation used the HAZUS-MH MR2 methodology but conducted those calculations externally to ensure the model for those particular social losses was used properly.

In Alabama, the CUSEC study estimates over three times as many displaced residences and temporary shelter needs as compared with this study. Alabama casualties show similar trends as CUSEC estimates 72 total casualties, while this investigation shows only 30. Though the hazard is shifted closer to the State of Alabama, in the scenario utilized in this investigation the shaking experienced throughout the state is minor and does not affect social impact assessments substantially. Finally, this investigation estimates greater direct economic loss by roughly $300 million, which is likely due to the additional utility inventory and the shifting of the hazard closer to the State of Alabama.

The scenario for the State of Arkansas is not shifted and utilizes the same scenario ground motion as the CUSEC scenario. Estimates of debris generation are roughly the same though sheltering estimates vary greatly. This investigation estimates that nearly 127,000 households are displaced and over 37,000 people will seek temporary shelter though CUSEC reports only 48,000 and 14,000 for these categories, respectively. This is likely due to the incorrect internal calculation of these values in HAZUS-MH MR2. When calculated externally, according to the HAZUS-MH MR2 model, estimates are substantially greater. CUSEC predicts roughly 15% more total casualties, though that is likely due to the large number of minor injuries. This investigation shows 130 more fatalities and several serious injuries (Level 3), which is likely due to the lowering of the seismic design level (moderate to low seismic design) in northeastern Arkansas. Though this investigation and the CUSEC study show total direct economic losses are roughly the same, buildings losses illustrate a sizeable difference of approximately $850 million. This is attributed to the lower seismic design specification in this investigation that makes buildings more vulnerable to earthquake damage.

Kentucky shows similar trends to those seen in Arkansas. Estimates of social impacts and induced damage are much greater in this investigation than in the CUSEC study. Debris estimates are roughly twice as much in this investigation, while displaced household and temporary housing estimates in this investigation are nearly three times those shown in the CUSEC study. Furthermore, casualty estimates are substantially more in this investigation, with over 12,500 total casualties, while CUSEC estimates are nearly 4,700.

Such differences in social impacts and induced damage are likely due to the location of the hazard. In this investigation the fault rupture is shifted closer to Kentucky and generates more intense shaking in the western portion of the state. The shifting of hazard, adjustment of seismic design class and addition of utility inventory produced the nearly $28 billion difference in total direct economic loss. This investigation estimates roughly $33.5 billion in losses while the CUSEC study shows only $5.8 billion. A more accurate representation of regional inventory in conjunction with the nearest fault rupture generates a substantial difference in economic loss.

As with many other southern states that experience significant impacts from a NMSZ earthquake, social impact estimates in Tennessee are far greater in this investigation than in the CUSEC study. Debris estimates are roughly 33% greater while sheltering and displaced household estimates are doubled. A total of 10,000 more casualties are expected in this investigation, with nearly 800 more fatalities estimated.

This investigation produces estimates for social impacts that are far greater in many central and northern NMSZ states. As mentioned earlier, the CUSEC study only employed the southwest event so central and northern states will experience less intense shaking in the CUSEC study than in this investigation. In the State of Missouri, CUSEC estimates approximately 25,000 displaced households, while this investigation anticipates nearly 122,000. In addition, CUSEC expects roughly 8,000 total casualties, while this investigation reports over 15,600 casualties. The same is true in Illinois where the northeast event is likely to generate the most catastrophic impacts. The CUSEC study reports roughly 5,000 displaced households and nearly 1,400 requirements for temporary housing. This investigation, on the other hand, estimates over 51,000 displaced households and 14,700 requirements for temporary housing. Furthermore, total direct economic losses in the State of Illinois are estimated at $2.2 billion in the CUSEC study, while this investigation estimates losses of around $31 billion. It is clear that the difference in source rupture makes a substantial difference in the social impacts and direct economic losses experienced by a state: thus, choosing the appropriate event is critical in determining the worst case impacts in a specified region. For additional comparison data, please refer to Appendix IX.

Additionally, the IEMA study provides a different, yet plausible set of social and economic losses than those presented in this report. This report estimates nearly 15,000 people will seek temporary shelter while the IEMA report estimates only 6,500 people seek temporary shelter. Conversely, this report estimates approximately 6,300 total casualties and the IEMA study estimates roughly 7,600 total casualties. Direct economic losses also differ, particularly utility lifeline losses. The substantially larger utility lifeline inventory utilized in this report generates nearly $27 billion in utility lifeline losses while the IEMA study shows only $2 billion in losses. For more information on the social and economic losses in the IEMA study, please refer to Mid-America Earthquake Center (2007) report.

Discussion and Conclusions

This investigation employs ten scenarios designed to identify the effects of plausible earthquakes on eight states in the Central USA. Eight of the ten scenarios focused on the New Madrid fault system while two scenarios represent the risk from the Wabash Valley and the East Tennessee seismic zones. In several cases, the fault rupture was moved to the boundaries of the NMSZ in an effort to capture the worst case impacts for each individual state. In addition, liquefaction susceptibility characterization, inventory updates and advanced social impact modeling were incorporated to provide the most reliable impact assessment possible. Though numerous scenarios have been completed, it is important to emphasize that impacts from each scenario should not be combined for regional assessment. With each scenario employing a different earthquake (hazard), even within the NMSZ, adding all impacts together represents an event that could not take place. On the other hand, it could be argued that the 1811-1812 earthquakes were three consecutive and potentially damaging events that current modeling tools are incapable of representing. Emergency planning, response and recovery decision-makers should weigh these factors in their efforts to balance the potentially conservative and non-conservative assumptions that are inevitable in a large regional study of earthquake impacts such as that described in the current report. For further discussion of the background of the scenarios used in this study, reference is made to the Scenario Disclaimer in page iv of this report.

The counties nearest to the source of seismic activity are likely to experience substantial damage to buildings as well as loss of critical services. This means that tens of thousands of homes will be damaged and residents will be displaced. For an earthquake nucleating in the northern portion of the NMSZ zone, thousands of buildings in southern Illinois and portions of Missouri and Kentucky will be damaged and tens of thousands will be without homes. The same is true for a southern NMSZ event, though in this case the heavily damaged areas will be northeast Arkansas, northwest Mississippi, western Tennessee and portions of western Kentucky. In addition, Memphis, TN, will be heavily damaged and its large number of highly vulnerable unreinforced masonry buildings will be significantly affected. This southern segment earthquake is likely to damage the greatest number of homes and affect the largest number of people when considering each individual segment rupture in the NMSZ.

Critical infrastructure and lifelines will also be heavily damaged and will be out of service after the earthquake for a considerable period of time. Such mass outages are likely to affect a region much larger than the 8 states studied above. Many hospitals nearest to the rupture zone will not be able to care for patients, indicating that those injured during the event will have to be transported outside of the region for medical care. Moreover, pre-earthquake patients will have to be moved out of the area to fully-functioning hospitals. It is doubtful that the transportation system will be functioning to a level that allows such mass evacuation. Police and fire services will be severely impaired due to damage to stations throughout the impacted region. Many schools that serve as public shelter will be damaged and unusable after the earthquake. Transportation into and

out of the areas near the fault rupture will be difficult if not impossible. Many bridges will be damaged and not passable, airports will be damaged and some ferry facilities and ports will be out of service. The massive loss of functionality of transportation systems and facilities will prevent displaced residents from leaving the region and also make it difficult for ground-transported aid workers and relief supplies to access the most heavily damaged areas.

Utility services will be severely disrupted for hundreds of thousands of customers due to extensive facility and pipeline damage. Extended service outages will be highly likely for tens of thousands of customers, making it difficult for them to remain in their homes, even if they are structurally sound after the earthquake. Damage to major natural gas and oil transmission lines will lead to service interruptions that will affect areas as far away as the east coast and New England.

Social impact estimates show that hundreds of thousands of people will be displaced and tens of thousands of people will seek temporary public shelter after a major earthquake on the New Madrid fault. Three successive earthquakes, as in 1811-1812, will generate even more catastrophic impacts. Casualties in the tens of thousands are likely, especially with a southwest segment rupture. Most of these will be minor injuries, though several thousand serious injuries and fatalities are also predicted. In addition, debris generated from this event may reach several hundred thousands tons, which will have to be removed prior to repair and reconstruction efforts.

Areas nearest to the rupture will be heavily damaged and many transportation and utility lifelines will not function for an extended period of time. The parts of each state that are farthest from the rupture will remain largely undamaged and functioning. Expectations are that these undamaged regions will support the response and recovery of the severely damaged areas. In addition, Indiana and Alabama are not likely to experience significant damage from a NMSZ event and may also function as host states in the aftermath of a NMSZ earthquake. Should an ETSZ or WVSZ event occur however, these states will require assistance from neighboring states.

Implications on Research and Development

The detailed study presented in this report has highlighted several areas where significant effort is called for, in order that more realistic and reliable earthquake consequence assessment results may be available in the foreseeable future. The most pressing of these research and development products are listed below, in the sequence of Hazard, Fragility, Inventory and Social and Economic Consequences:

- Several major assumptions were made on the hazard side to account for the multiple earthquake potential of the New Madrid Seismic Zone. Fundamental research in earthquake geophysics and engineering seismology is needed to assess the relative probabilities of occurrence of earthquake occurrence on the three identified segments of the NMSZ and the implications of one earthquake on the probabilities of the second and third earthquakes happening. This is a complex problem that pushes the

boundaries of time-dependent hazard and multiple source modeling, amongst other challenges.

- Detailed liquefaction characterization that uses state-of-the-art liquefaction metrics is sorely needed. The difficult problem of characterizing liquefaction is compounded by the multiple earthquake occurrences which require new approaches to account for the cumulative effect of multiple earthquakes.
- The above two research issues lead to a third important point, which is the effect of multiple earthquakes on site response that may effectively alter the site class in such a manner so as to annul the strong-motion (attenuation) models in current use. Research is required to address this problem and provide reliable ground motion parameters.
- Significant improvements in inventory are still urgently required. There are many systems that are critical for response and recovery for which inventory is either sparse or lacking. Examples are utilities distribution networks that are not in the public domain and cell phone towers. It is clear that without accurate inventory, modeling efforts will continue to be relatively uncertain.
- There are several important built environment components for which no fragility relationships exist, such as different configurations of gravity and earth dams, large and complex river crossings, special structural configurations used for power and chemical plants and their components, communications and electricity towers, amongst others. Such fragilities are urgently required.
- For all fragilities used in assessment in the New Madrid Seismic Zone, the effect of degradation in stiffness and strength due to multiple earthquakes poses a fundamental and intricate research challenges that should be addressed urgently. The current approach is grossly inaccurate, and it is not possible to ascertain if it is conservative or otherwise, since the interaction between input motion and structural frequencies is highly nonlinear.
- The sheltering model employed was developed based upon behavior exhibited in the San Francisco bay area following the Loma Prieta earthquake and in the Los Angeles area after the Northridge earthquake. The model has not been tested or validated outside of California. There is a large amount of uncertainty regarding the factors that influence the reasons for shelter-seeking. This model assumes that people will only seek shelter if their homes have been damaged. It neglects other factors that make it difficult to sustain themselves in their own homes such as loss of power or water, safety factors, damage to surrounding hazardous materials facilities and long term recovery.
- During the response phase of the disaster management cycle, the prioritization of service needs will change. Over time focus will move from life-saving to life-sustaining and finally life-supporting. The uncertainty regarding the length of time that will be required to deliver services during a catastrophic event is very high. The transition from response to recovery takes much longer during a catastrophe. Midterm economic effects are prolonged due to factors such as loss of infrastructure, loss of jobs, etc. More research is needed on speed-of-recovery factors of the socio-economic systems. The response models currently focus on immediate responses and are not validated for longer time frames. Consideration of long term commodity distribution, medical services, and repair of cascading infrastructure failures is required.

- Current preparedness goals are based on establishing adequate response system capabilities. The objective of response should be to successfully achieve observable and measurable goals. In order to do this, response managers must achieve critical success factors and avoid critical failures. The outcome-based metrics required to establish goals and to manage for success do not exist. The modeling and estimation of disaster caused needs conducted in this project can provide the basis for establishing these metrics and for developing outcome-based response strategies.
- Comprehensive and theoretically sound measures of reliability of the loss assessment, taking into account uncertainties in all components, are urgently needed. Attaching a reliability measure to the impact estimate is essential for informed decision-making.

In general, disasters that lead to catastrophic consequences produce cascading infrastructure failures which may result in unanticipated response requirements. Infrastructure failures not only influence the demands for service but also the mobility and capabilities of response organizations attempting to provide these services. There is a dearth of information on the manner in which people and systems behave following a catastrophe. There is a pressing need for collection and assimilation of such information possibly from other regions in the world with social and economic characteristics similar to the Central USA.

Acknowledgements

This report summarizes a considerable amount of work that includes various sub-disciplines. As such, it has benefited from the contributions of many individuals and organizations. It is impossible to include a comprehensive list; every attempt was made to list individuals and organizations under the heading of 'Contributions' in the opening part of this report, and below. Financial support was provided by FEMA through the US Army Corps of Engineers Civil Engineering Research Laboratory at Urbana, Illinois. Additional supporting resources were made available by the Mid-America Earthquake Center through its Emergency Management Agencies test bed project, funded by the National Science Foundation. The Project Team wishes to thank Mr. Michel S. Pawlowski for leading the FEMA oversight effort, Dr. Ilker Adiguzel and Dr. James Wilcoski (USACE), the IEM group, Mr. James Wilkinson (CUSEC), Mr. Douglas Bausch (FEMA Region VIII) and Mr. Robert Bauer (Illinois State Geological Survey). Thanks are also due to state emergency management offices, state geological surveys, the four relevant FEMA regions, PBS&J Corporation, and administration and finance personnel at the University of Illinois, both at the Civil and Environmental Engineering Department and the Campus.

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Appendix I: Shaking Maps

This appendix details the development of shaking maps for all scenarios employed in the MAEC-GWU State reports for earthquake planning workshops in New Madrid Seismic Zone States. A total of ten scenarios have been completed and the sets of shaking maps used for these scenarios are included. HAZUS-MH MR2, the analytical loss assessment software used, requires four shaking parameters to perform an analysis. These parameters are peak ground acceleration (PGA), peak ground velocity (PGV), short-period spectral acceleration (S_a 0.3 sec.) and long-period spectral acceleration (S_a 1.0 sec.).

Each set of shaking maps is explained separately in following discussion. Most shaking maps were created by the USGS and modified by the MAEC. These modifications are quantified in this appendix. Shaking maps that were developed by the MAEC are also discussed and the creation process detailed.

At the conclusion of this appendix is a series of maps. Original USGS and MAEC adjusted maps are shown, for those scenarios that relied on USGS maps. All shaking maps created by the MAEC are also included.

Alabama – New Madrid Seismic Zone Event

The earthquake impact assessment for the State of Alabama employs one scenario event along the New Madrid Fault. The scenario consists of a M7.7 earthquake along the southwest segment of the presumed New Madrid Fault system. The ground motions used to represent this seismic event were developed by the USGS for the middle fault in the proposed NMSZ. Each fault line is presumed to consist of three fault segments: northeast, central and southwest. The worst case scenario for the State of Alabama, and the critical counties in particular, is an event on the eastern fault line in the southwest segment. The USGS southwest extension map is shifted from the middle fault to the eastern fault line according to the following parameters:

- Geographic coordinate system: GCS_North_America_1983
- Southwest Segment – Eastern Fault Line
- Central Meridian: -92.7
- Scale Factor: 1.005

Portions of Alabama are not covered by the shifted maps and require the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by the shifted USGS map, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second

- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Original USGS shaking maps for the southwest extension event in the State of Alabama are illustrated in this appendix. Maps shifted to the eastern fault are also illustrated in this appendix.

Alabama – East Tennessee Seismic Zone Event

This earthquake impact assessment for the State of Alabama employs one scenario event in Dekalb County. The scenario consists of a M5.9 earthquake in the East Tennessee Seismic Zone (ETSZ). The epicenter location and all soil and liquefaction data are provided by the Geologic Survey of Alabama (GSA). The epicenter chosen for this scenario is located at 34.446N, 85.617W. A set of five attenuation functions is used to generate ground motion. The attenuations and weighting factors are listed below:

Atkinson and Boore (1997)	0.250
Toro, Abrahamson and Schneider (1997)	0.250
Frankel, Mueller, Barnhard, Perkins et al. (1996)	0.250
Campbell (2002)	0.125
Sommerville, Collins, Abrahamson et al. (2002)	0.125

It is relevant to note that the attenuation from Frankel, Mueller, Barnhard, Perkins et al. (1996) cannot be computed for a magnitude of 5.9. The attenuation only applies to earthquakes with magnitudes of 6.0 or greater. In order to determine regional ground shaking with this attenuation, a magnitude of 6.0 was used. The four remaining attenuations employed a magnitude 5.9, as prescribed by GSA. This change does not impact the intensity of regional shaking significantly and is acceptable for the purposes of this assessment. Shaking maps for this scenario are illustrated in this appendix.

Arkansas – New Madrid Seismic Zone Event

The earthquake impact assessment for the State of Arkansas employs one scenario event along the New Madrid Fault. The scenario consists of a M7.7 earthquake along the southwest extension of the presumed New Madrid Fault system. The ground motions used to represent this seismic event were developed by the USGS for the middle fault in the proposed NMSZ. Based on the recommendation of the Arkansas State Geologic Survey, the southwest segment of the middle fault is taken to be the worst case scenario for the State of Arkansas, and no shifting of shaking maps is undertaken. Shaking maps for this scenario are illustrated in this appendix.

Portions of Arkansas are not covered by the USGSmaps and required the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by

these maps, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second
- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Illinois – New Madrid Seismic Zone Event

The earthquake impact assessment for the State of Illinois employs one scenario event along the New Madrid Fault. The scenario consists of a M7.7 earthquake along the northern segment of the presumed New Madrid Fault system. The ground motions used to represent this seismic event were developed by the USGS for the middle fault in the proposed NMSZ. The worst case scenario for the State of Illinois, for the critical counties in particular, is an event on the western fault line in the northern segment. The USGS northeast extension shaking maps are shifted from the middle fault to the western fault line according to the following parameters:

- Geographic coordinate system: GCS_North_America_1983
- Northeast Segment – Western Fault Line
- Central Meridian: -93.189
- Scale Factor: 0.994

Portions of Illinois are not covered by the shifted maps and required the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by the shifted USGS map, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second
- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Shaking maps for this scenario are illustrated in this appendix.

Indiana – New Madrid Seismic Zone Event

This scenario consists of a M7.7 earthquake along the northeast segment of the NMSZ. The ground motions used to represent this seismic event were developed by the USGS for the middle fault in the proposed NMSZ. The NMSZ scenario for the State of Indiana employs an event in the northeast segment of the eastern fault. Original USGS shaking maps are illustrated in this appendix, while shifted shaking maps are also illustrated in

this appendix. Shaking maps are shifted from the middle fault to the eastern fault according to the following parameters:

- Geographic coordinate system: GCS_North_America_1983
- Northeast Segment – Eastern Fault Line
- Central Meridian: -92.7
- Scale Factor: 1.003

Portions of Indiana are not covered by the shifted maps and required the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by the shifted USGS map, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second
- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Indiana – Wabash Valley Seismic Zone Event

This scenario consists of a M7.1 earthquake along the Wabash Valley Fault system. The ground motions used to represent this seismic event were developed by the USGS. The maps developed by the USGS cover the entire State of Indiana, and there is no need to assign shaking values as is carried out for other states. Wabash Valley Event shaking maps are illustrated in this appendix.

Kentucky – New Madrid Seismic Zone Event

This earthquake impact assessment for the State of Kentucky employs one scenario event along the New Madrid Fault. The ground motions used to represent this seismic event were developed by the USGS for the middle fault in the proposed NMSZ. The scenario consists of a M7.7 earthquake along one segment of the presumed New Madrid Fault system. The worst case scenario for the entire State of Kentucky is an event on the eastern fault line in the northeast segment. All USGS shaking maps for Kentucky are illustrated in this appendix and shifted maps are shown in this appendix. The USGS shaking maps are shifted from the middle fault to the eastern fault according to the following parameters:

- Geographic coordinate system: GCS_North_America_1983
- Northeast Segment – Eastern Fault Line
- Central Meridian: -92.7
- Scale Factor: 1.003

Portions of Kentucky are not covered by the shifted maps and required the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by the shifted USGS map, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second
- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Mississippi – New Madrid Seismic Zone Event

The scenario consists of a M7.7 earthquake along one segment of the NMSZ. The ground motions used to represent this seismic event were developed by the USGS for the middle fault in the proposed NMSZ. The NMSZ worst case scenario for the State of Mississippi employs an event in the southwest segment of the eastern fault. Shaking maps created by the USGS are illustrated in this appendix, while shifted maps for Mississippi are also depicted in this appendix. The original USGS maps are shifted to the eastern fault line according to the following parameters:

- Geographic coordinate system: GCS_North_America_1983
- Southwest Segment – Eastern Fault Line
- Central Meridian: -92.7
- Scale Factor: 1.005

Portions of Mississippi are not covered by the shifted maps and required the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by the shifted USGS map, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second
- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Missouri – New Madrid Seismic Zone Event

The earthquake impact assessment for the State of Missouri employs one scenario event along the New Madrid Fault. The scenario consists of a M7.7 earthquake along the central segment of the presumed New Madrid Fault system. The ground motions used to represent this seismic event were developed by the USGS for the middle fault in the proposed NMSZ. The worst case scenario for the State of Missouri is an event on the western fault line in the central segment. USGS maps for the middle fault are shown in

this appendix, and shifted maps are also shown in this appendix. Original USGS shaking maps are shifted to the western fault according to the following parameters.

- Geographic coordinate system: GCS_North_America_1983
- Central Segment – Western Fault Line
- Central Meridian: -93.53
- Scale Factor: 0.994

Portions of Missouri are not covered by the shifted maps and required the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by the shifted USGS map, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second
- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Tennessee – New Madrid Seismic Zone Event

The earthquake impact assessment for the State of Tennessee employs one scenario event along the NMSZ. The ground motions used to represent this seismic event were developed by the USGS. The scenario consists of a M7.7 earthquake along one segment of the NMSZ. The worst case scenario for the State of Tennessee is an event on an eastern fault line associated with the southern segment. The USGS maps for the middle fault are illustrated in this appendix, while the shifted maps are also shown in this appendix. Original USGS maps are shifted to the eastern fault according to the following parameters:

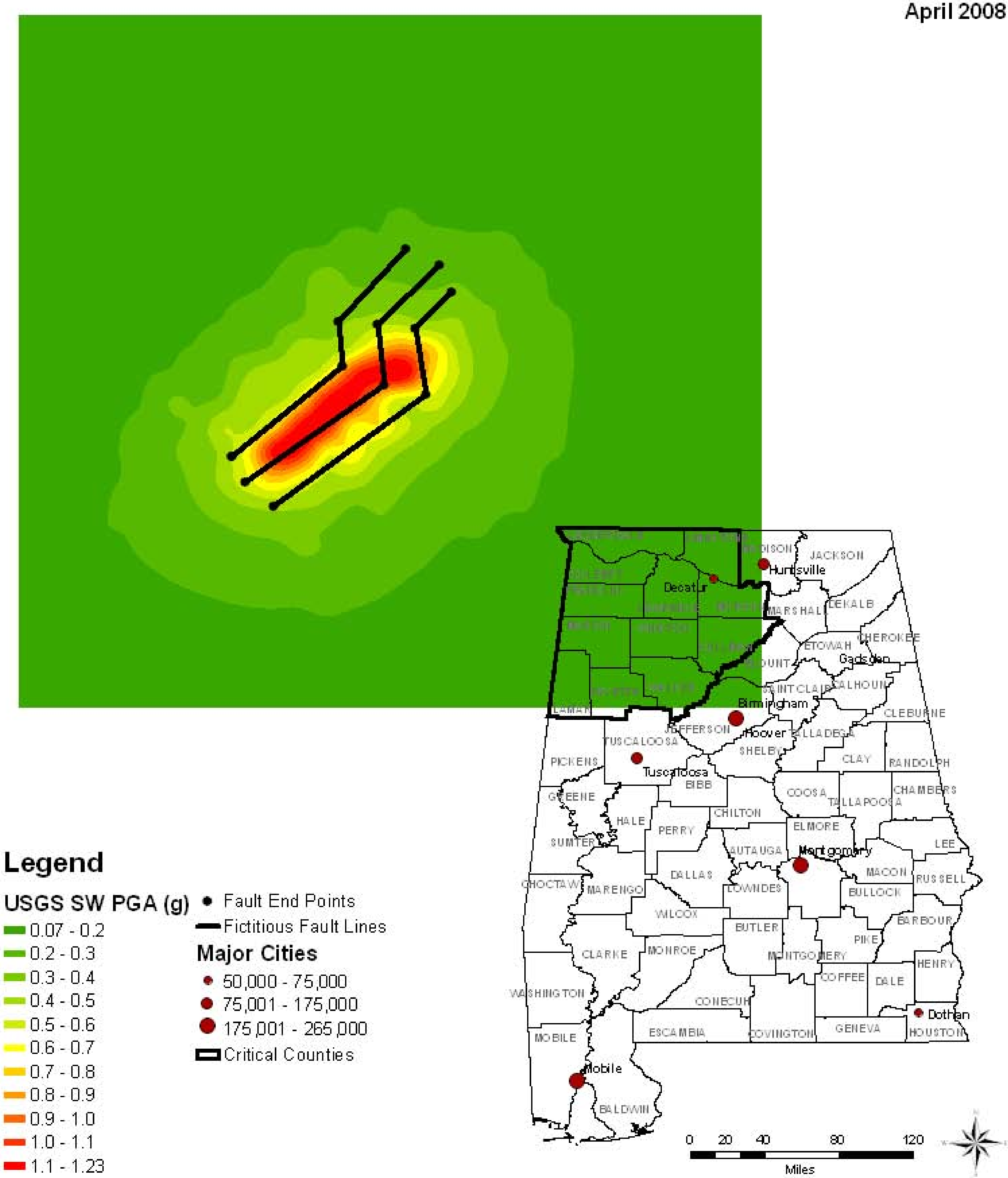
- Geographic coordinate system: GCS_North_America_1983
- Southwest Segment – Eastern Fault Line
- Central Meridian: -92.7
- Scale Factor: 1.005

Portions of Tennessee are not covered by the shifted maps and required the assignment of shaking values. Due to the low level of shaking experienced in the areas not covered by the shifted USGS map, the following values are applied to shaking parameters required by HAZUS-MH MR2:

- PGA: 5% of gravity
- PGV: 3 inches per second
- Spectral Acceleration @ 1 sec frequency: Set to 11% of gravity
- Spectral Acceleration @ 0.3 sec frequency: Set to 12% of gravity

Alabama PGA from USGS - New Madrid Seismic Zone: M7.7 Event

April 2008



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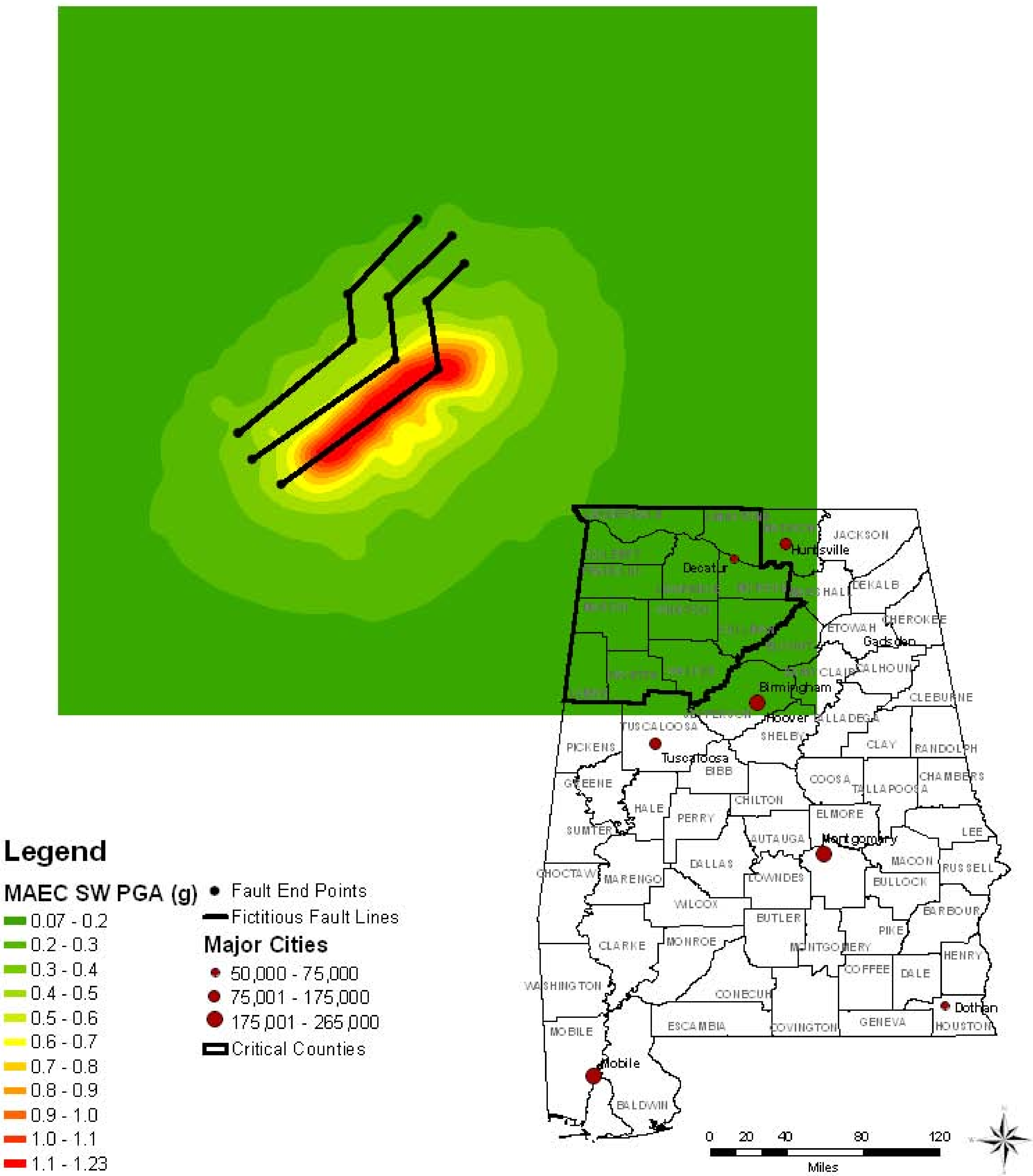
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Alabama PGA from MAEC - New Madrid Seismic Zone: M7.7 Event

April 2008



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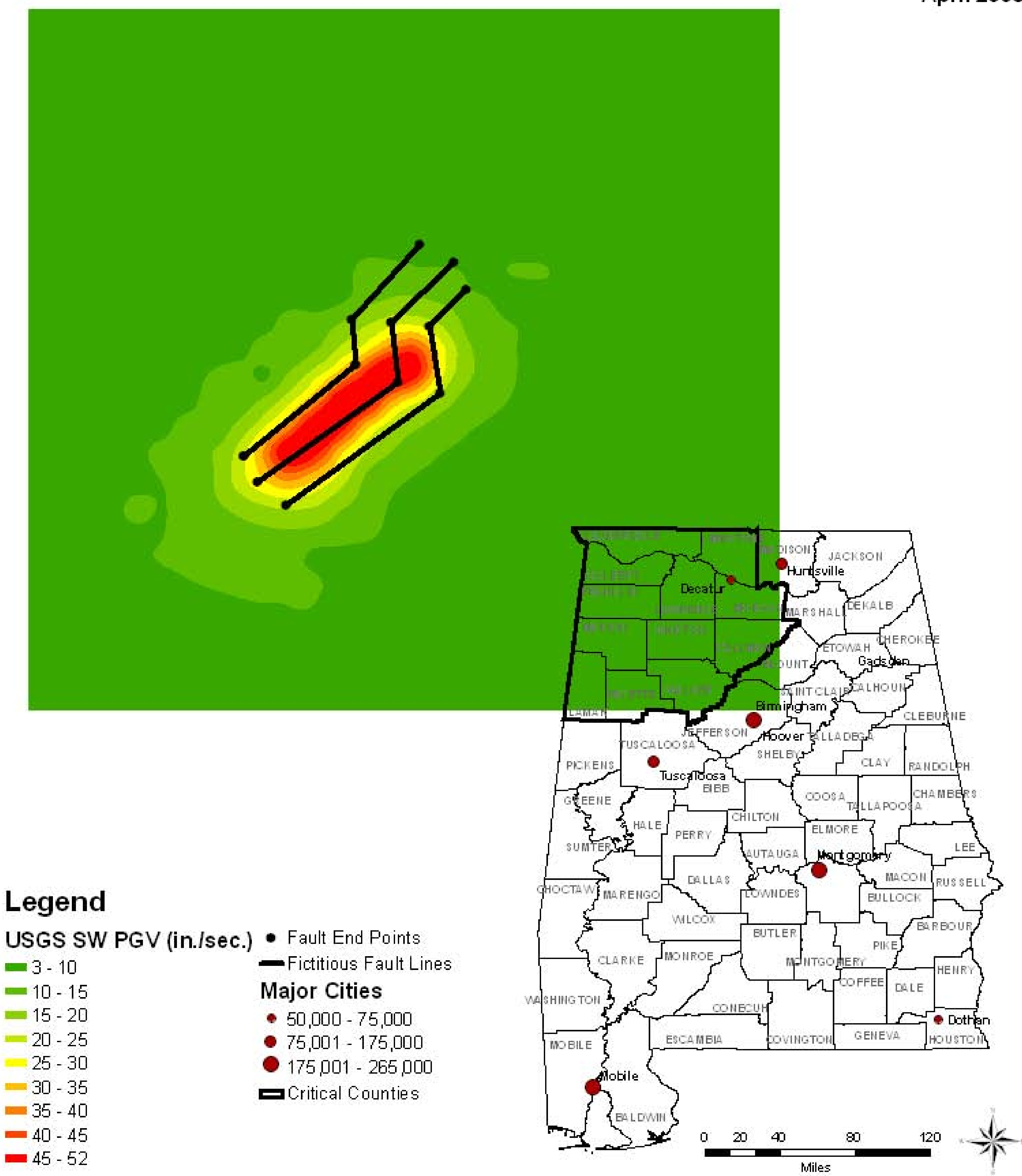
Alabama PGV from USGS - New Madrid Seismic Zone: M7.7 Event

April 2008



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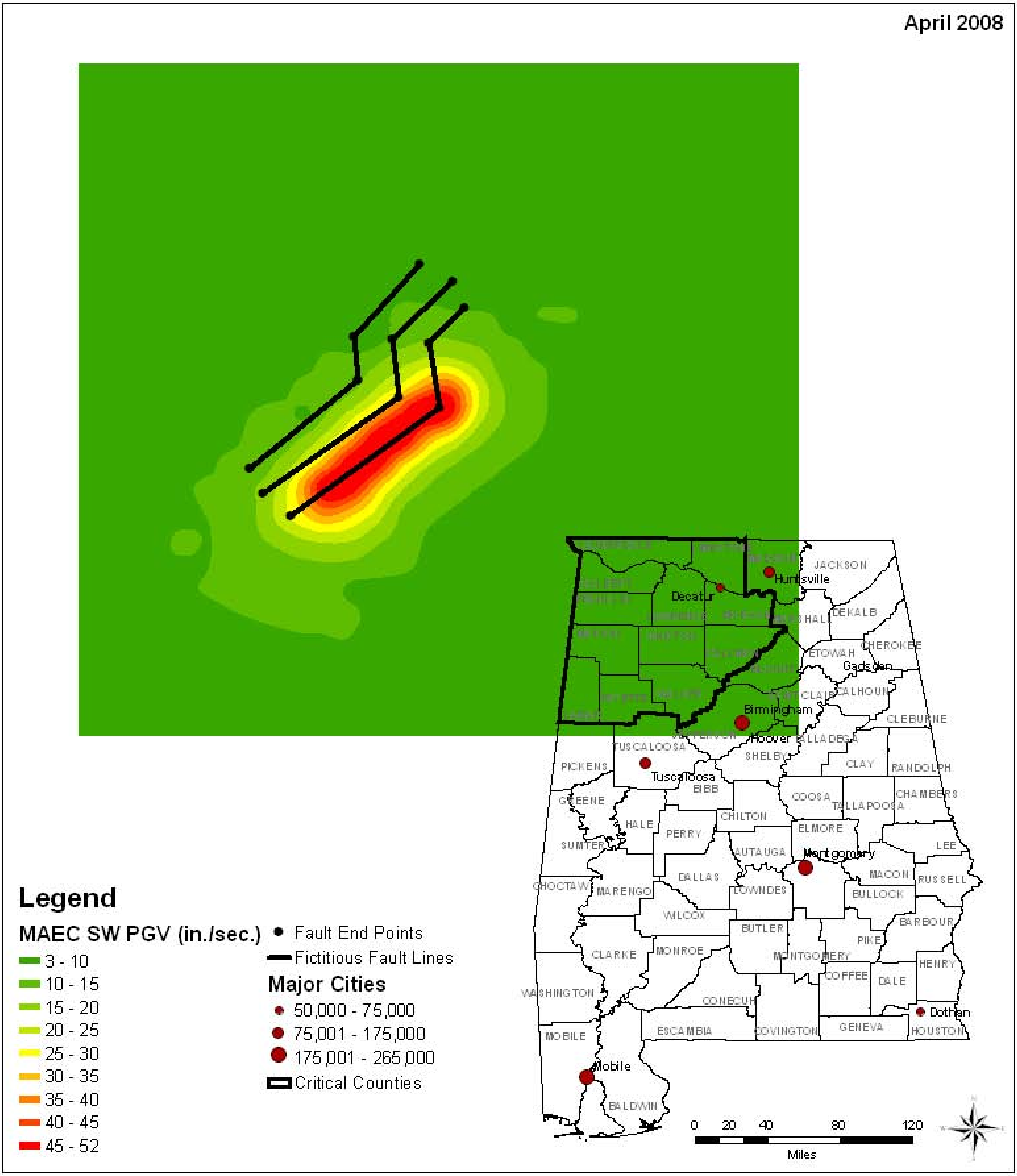
Alabama PGV from MAEC - New Madrid Seismic Zone: M7.7 Event

April 2008



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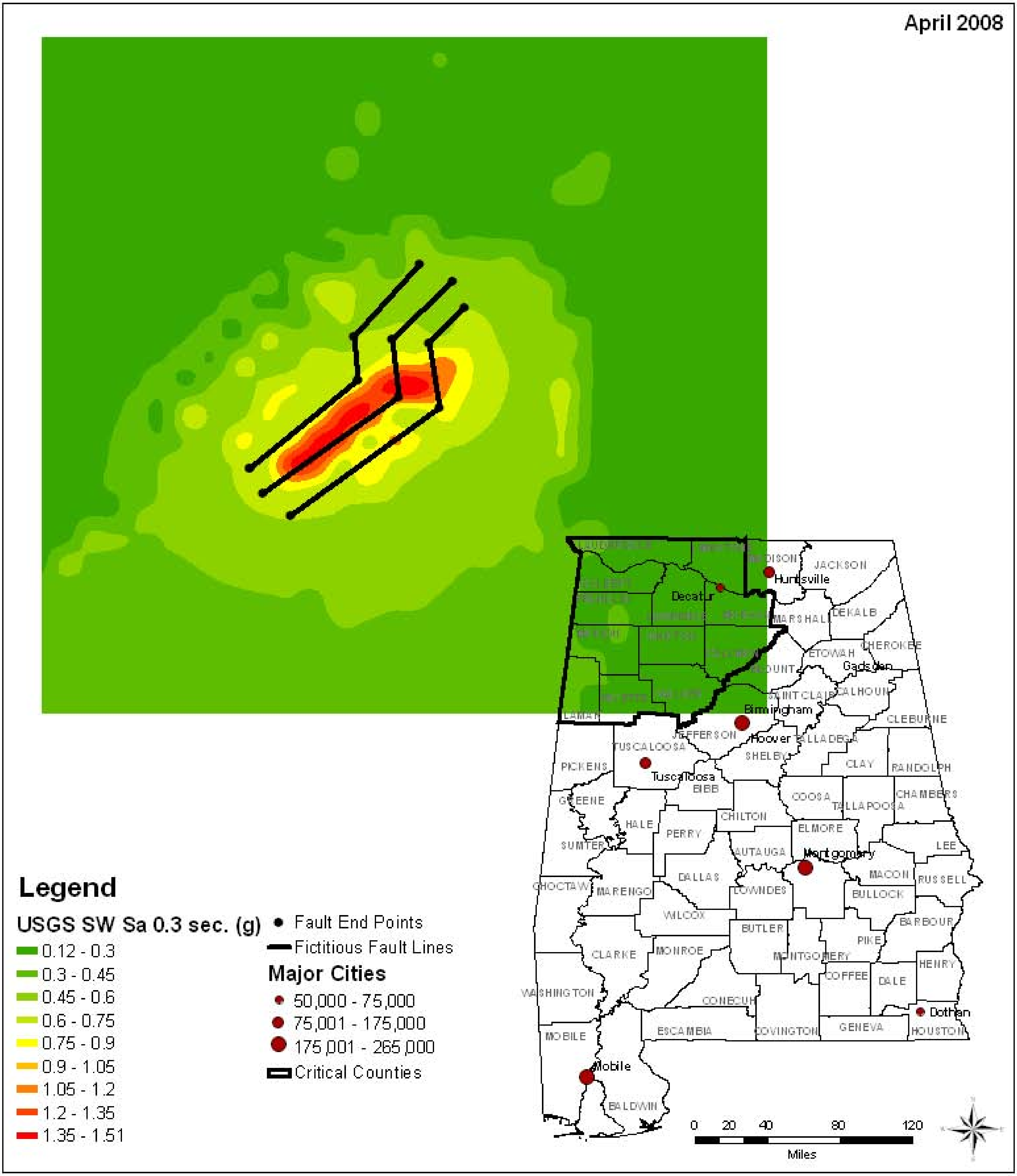
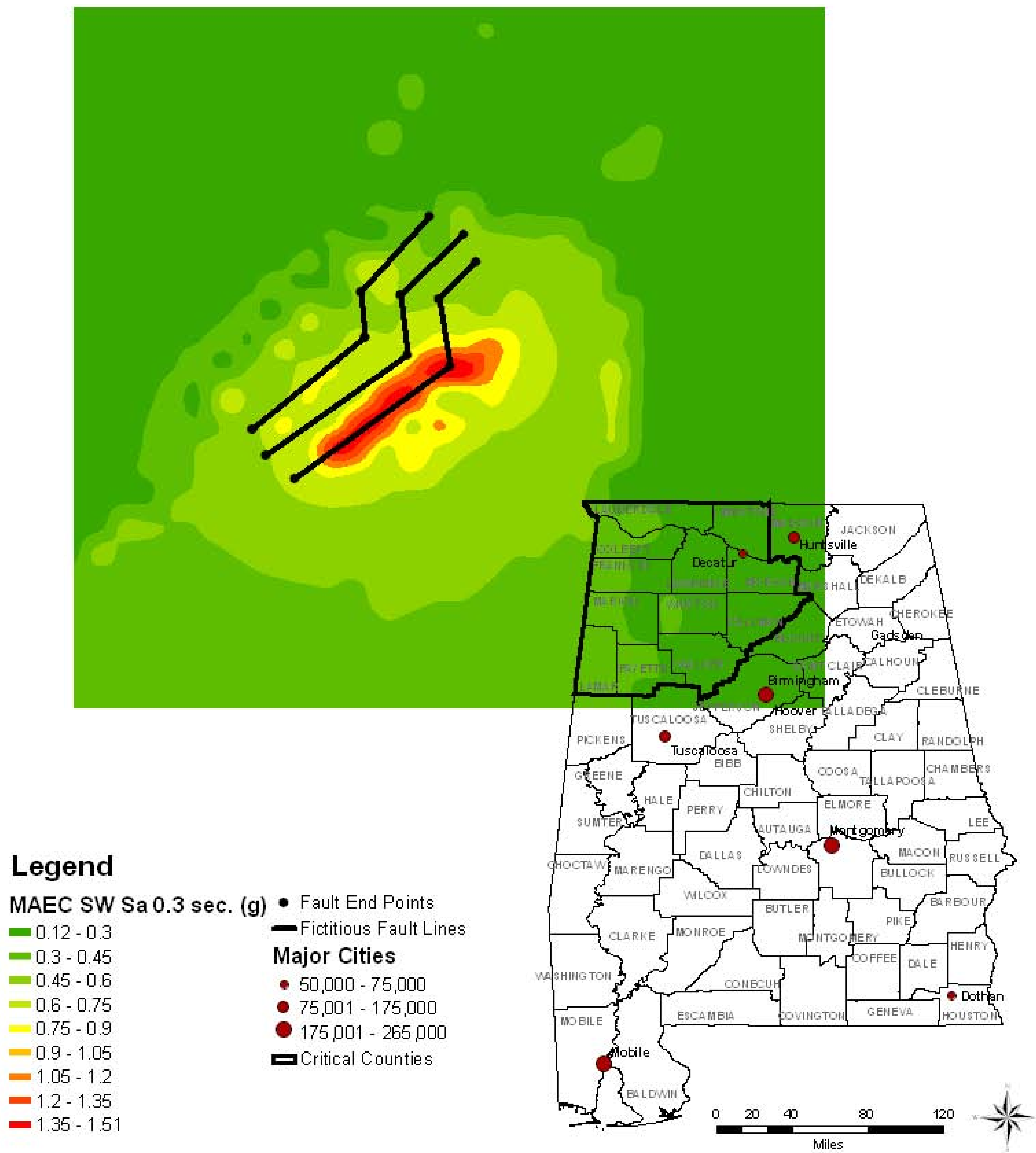
Alabama Sa 0.3 Sec. from USGS - New Madrid Seismic Zone: M7.7 Event



Alabama Sa 0.3 Sec. from MAEC - New Madrid Seismic Zone: M7.7 Event

April 2008



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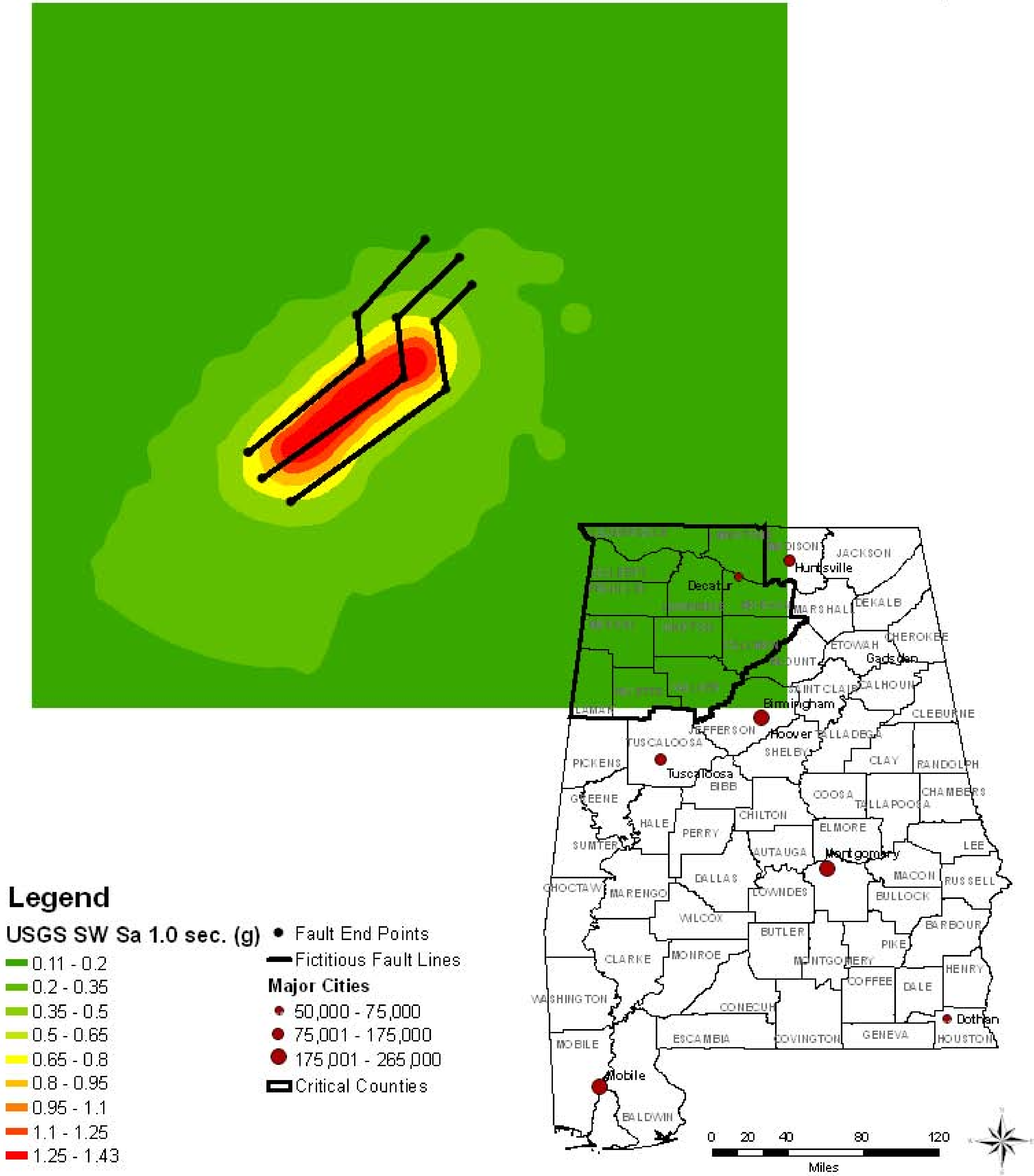
April 2008



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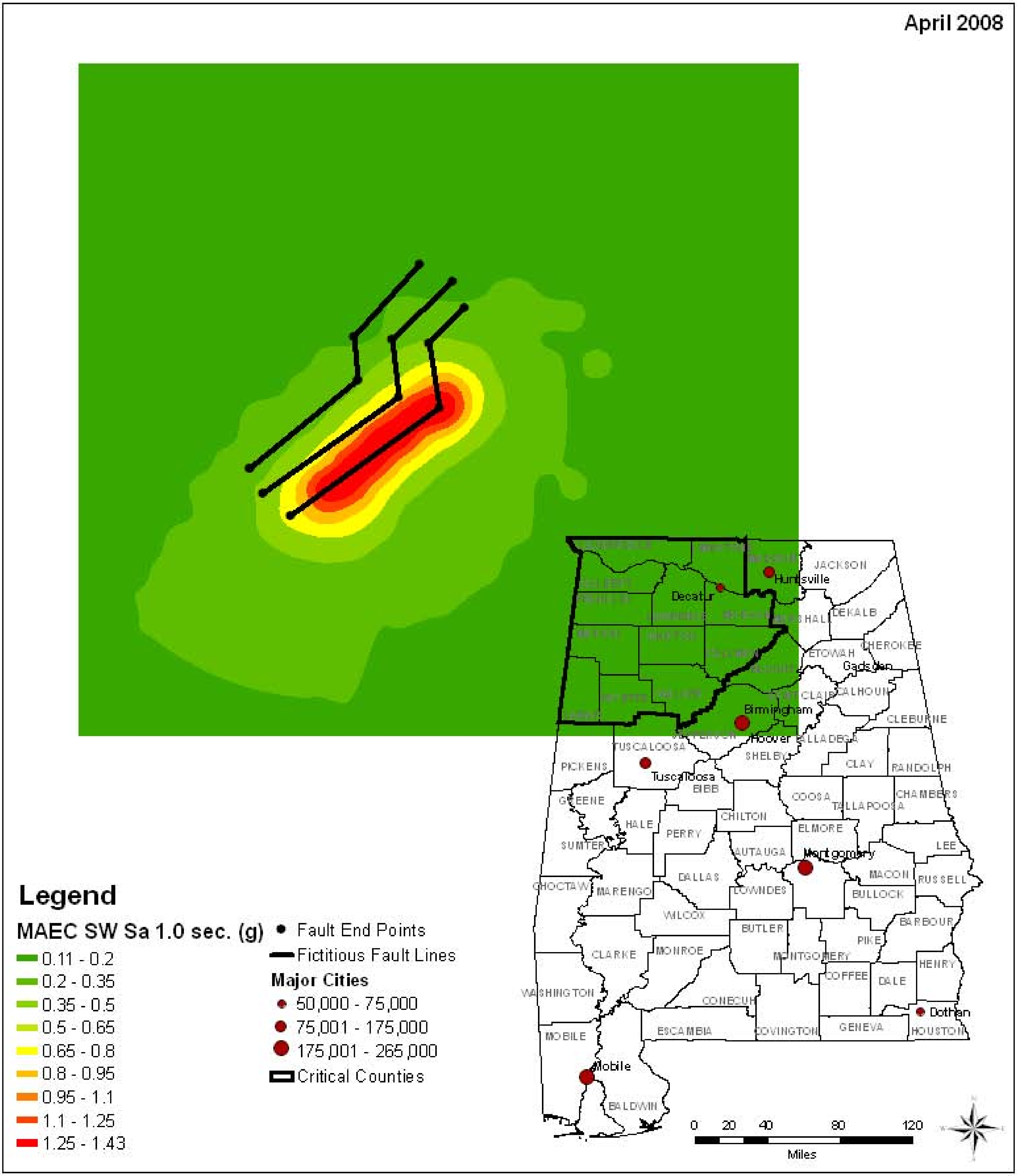
Alabama Sa 1.0 Sec. from MAEC - New Madrid Seismic Zone: M7.7 Event



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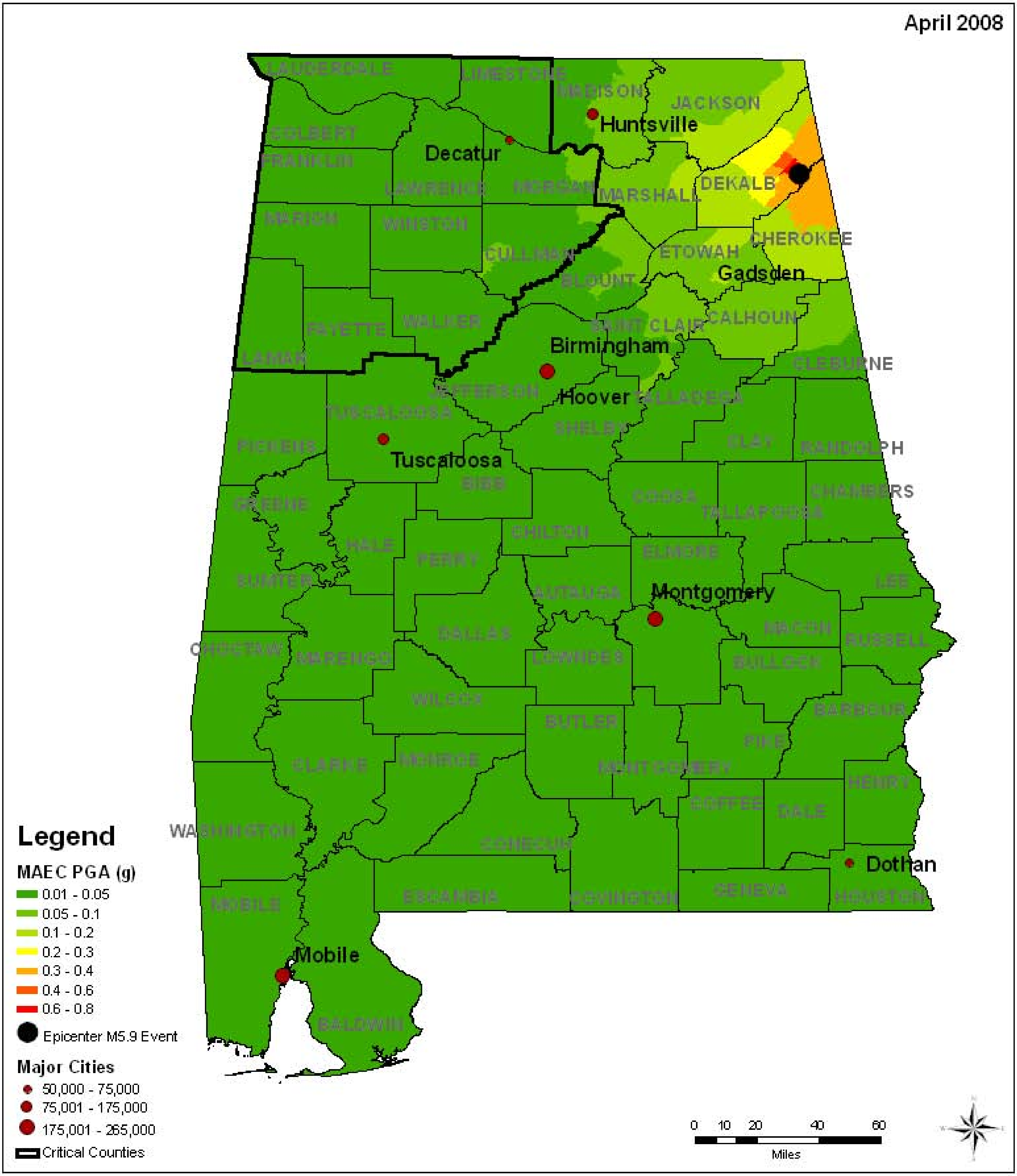
Alabama PGA - East Tennessee Seismic Zone: M5.9 Event



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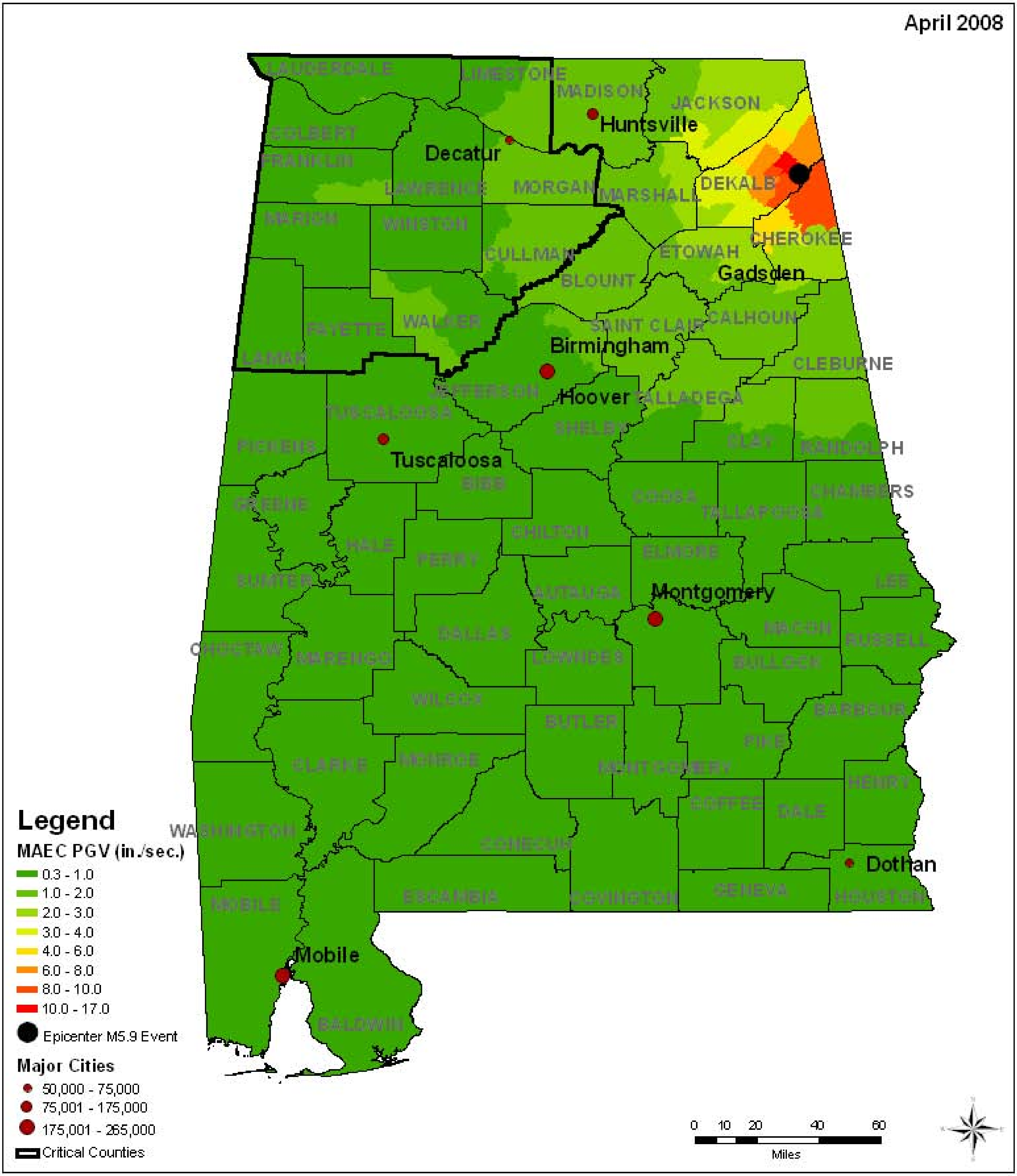
Alabama PGV - East Tennessee Seismic Zone: M5.9 Event



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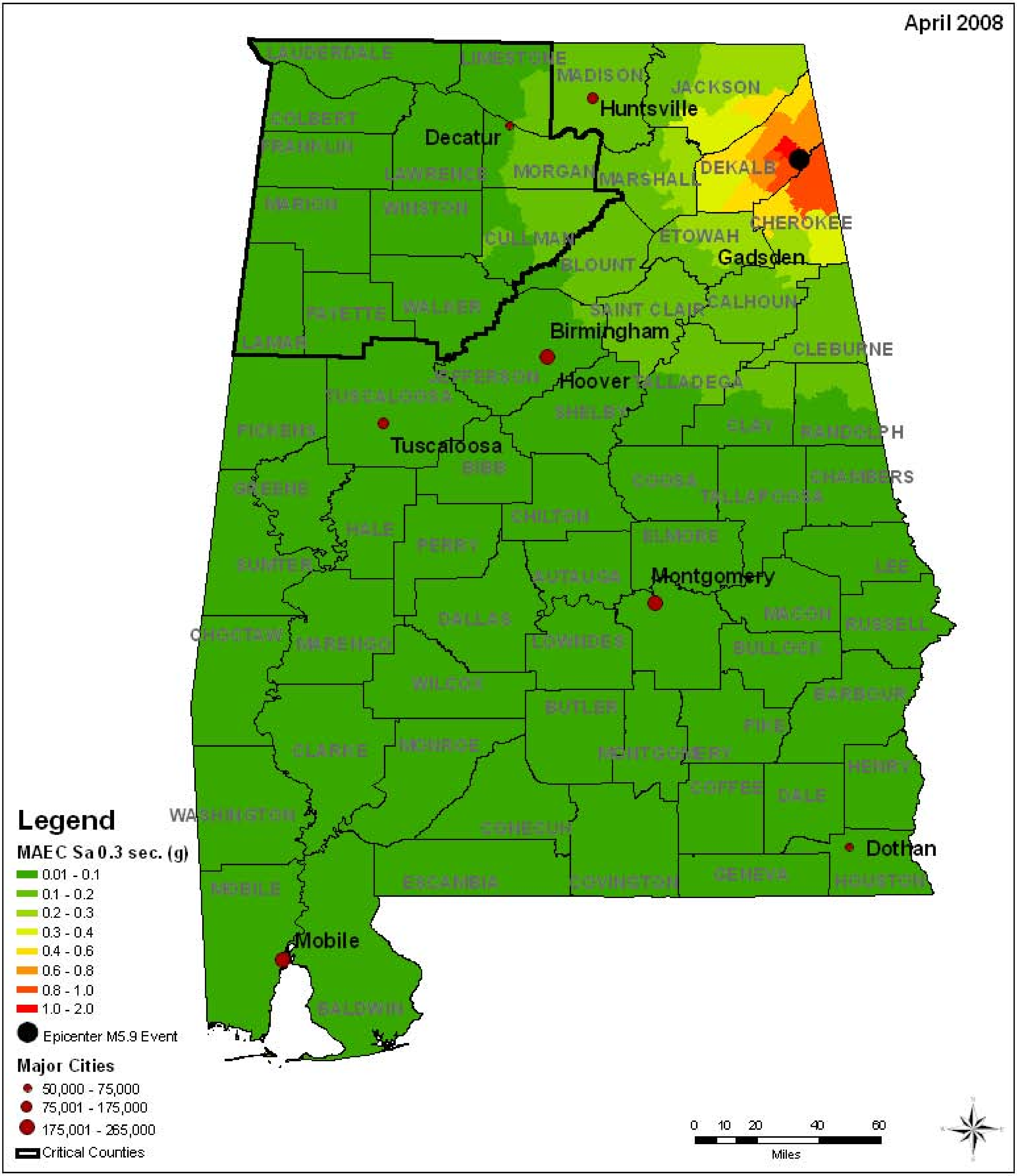
Alabama Sa 0.3 sec. - East Tennessee Seismic Zone: M5.9 Event



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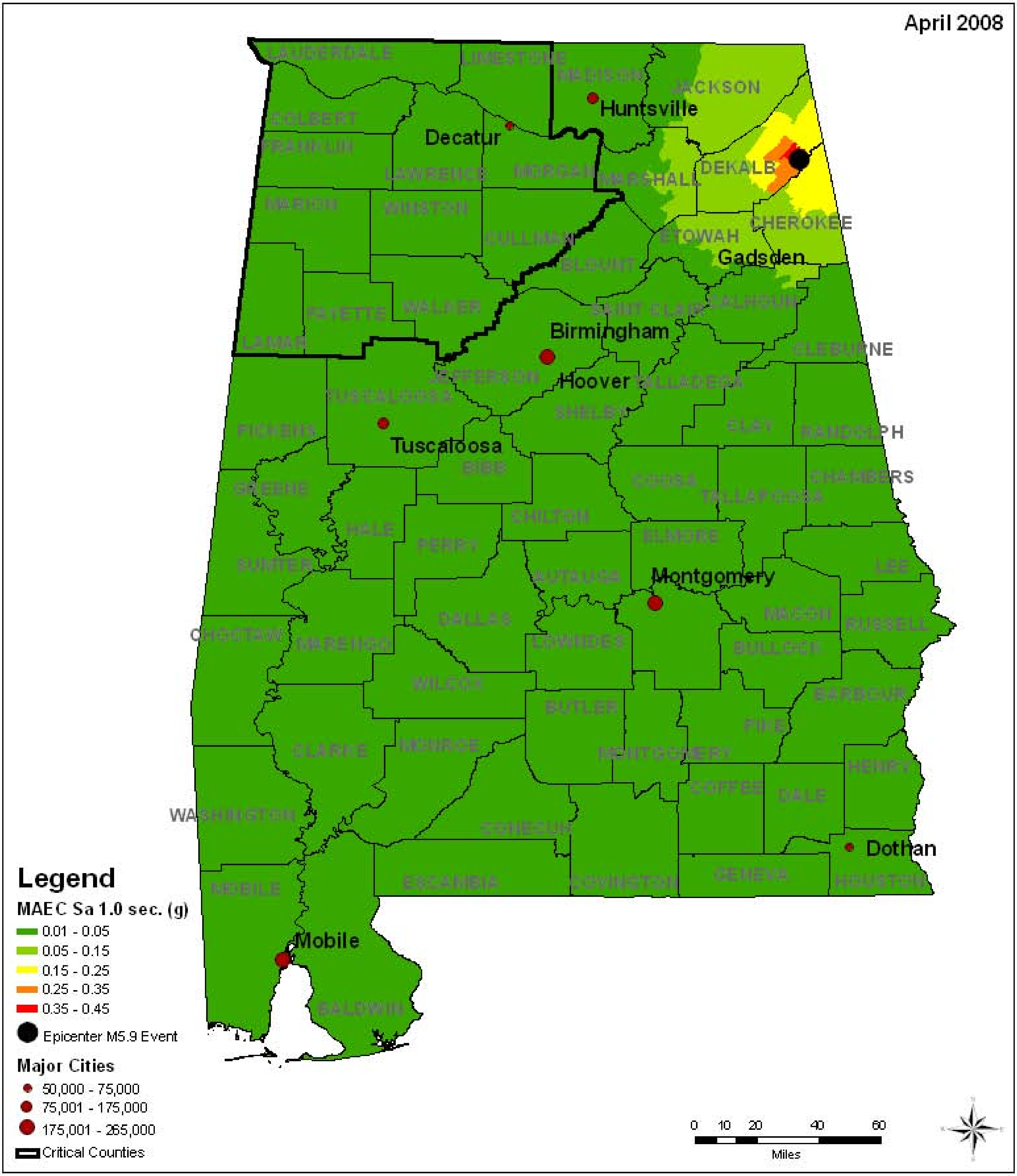
Alabama Sa 1.0 sec. - East Tennessee Seismic Zone: M5.9 Event



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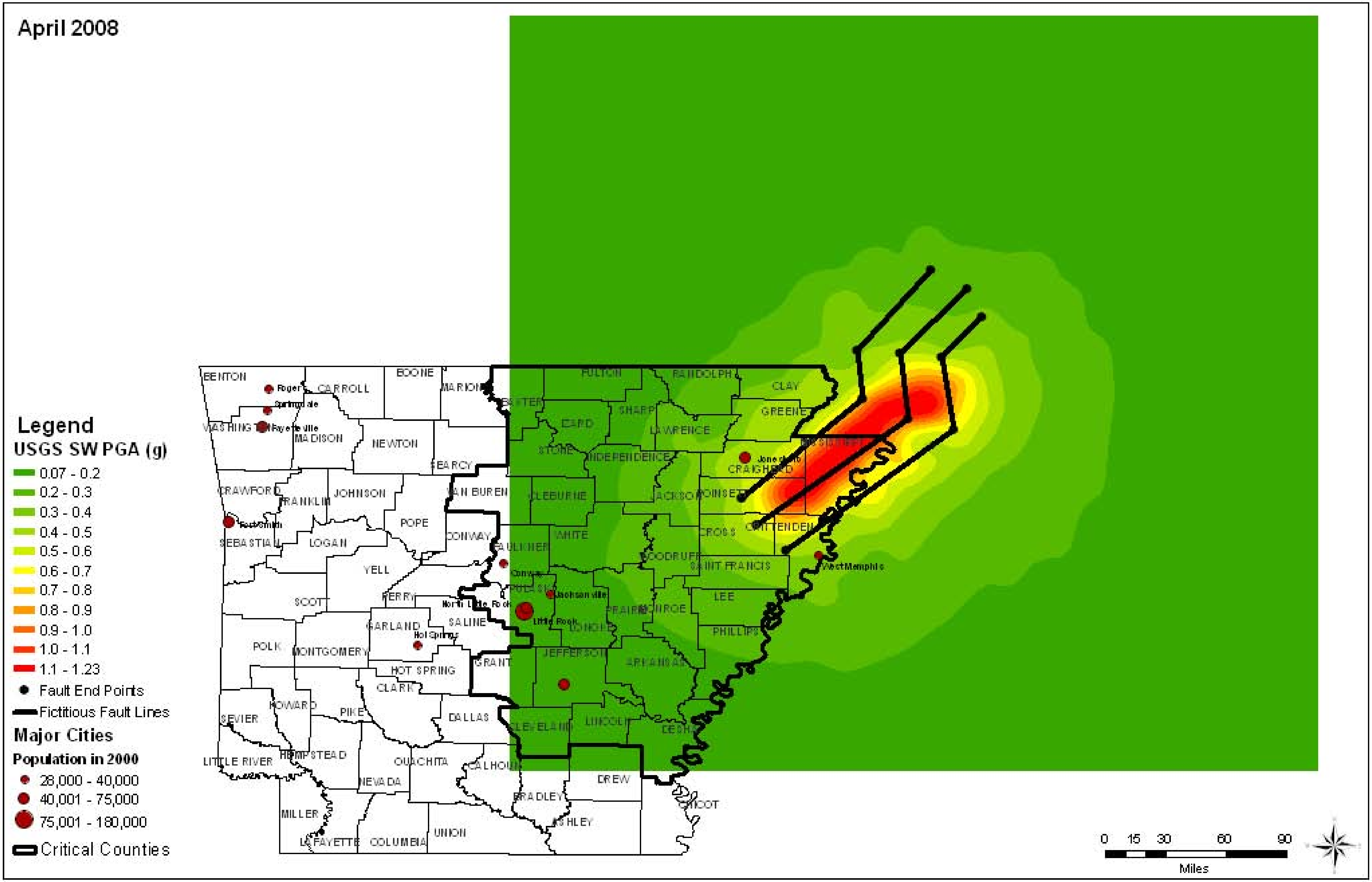
Arkansas PGA from USGS - New Madrid Seismic Zone: M7.7 Event



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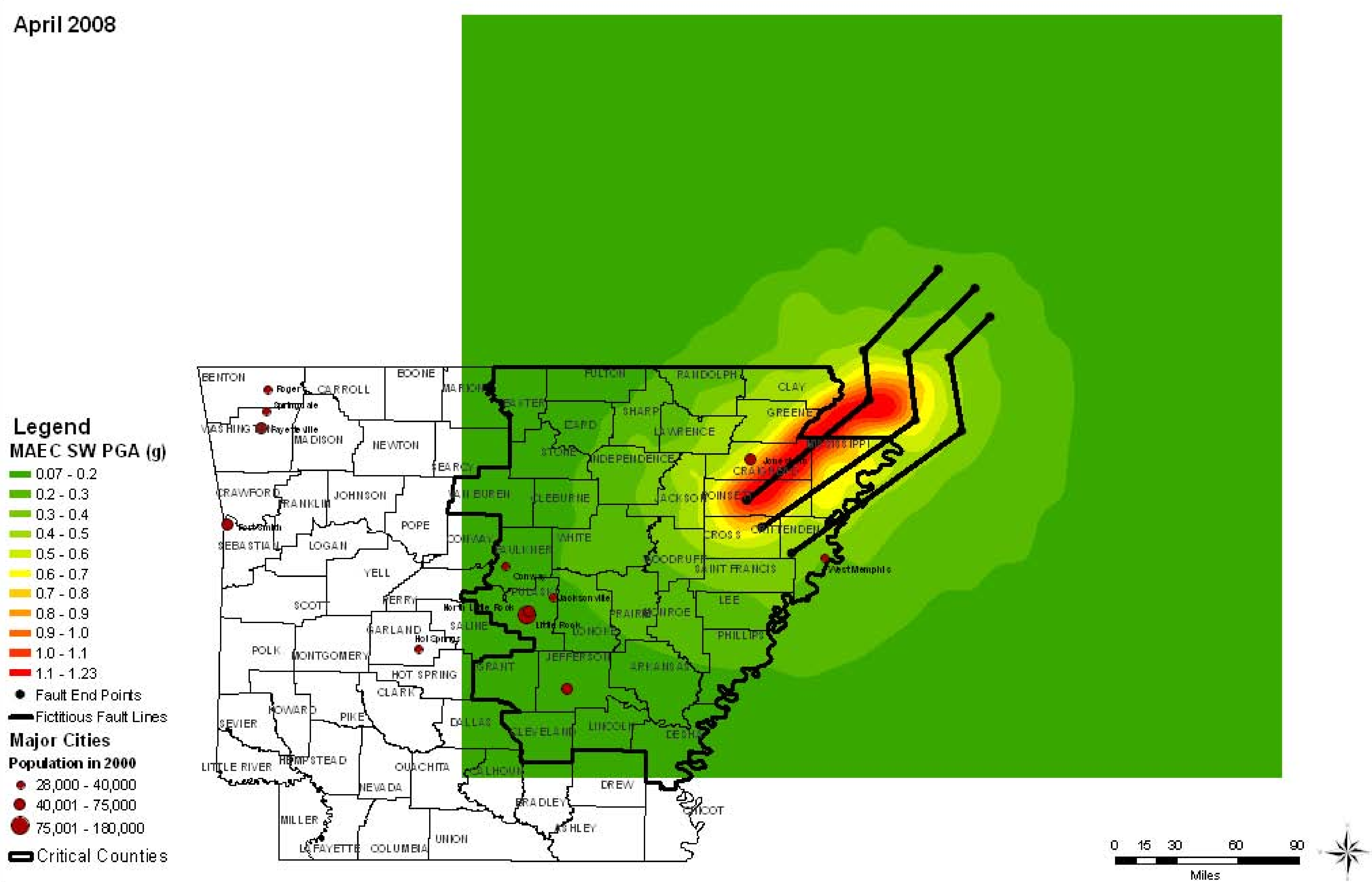
Arkansas PGA from MAEC - New Madrid Seismic Zone: M7.7 Event



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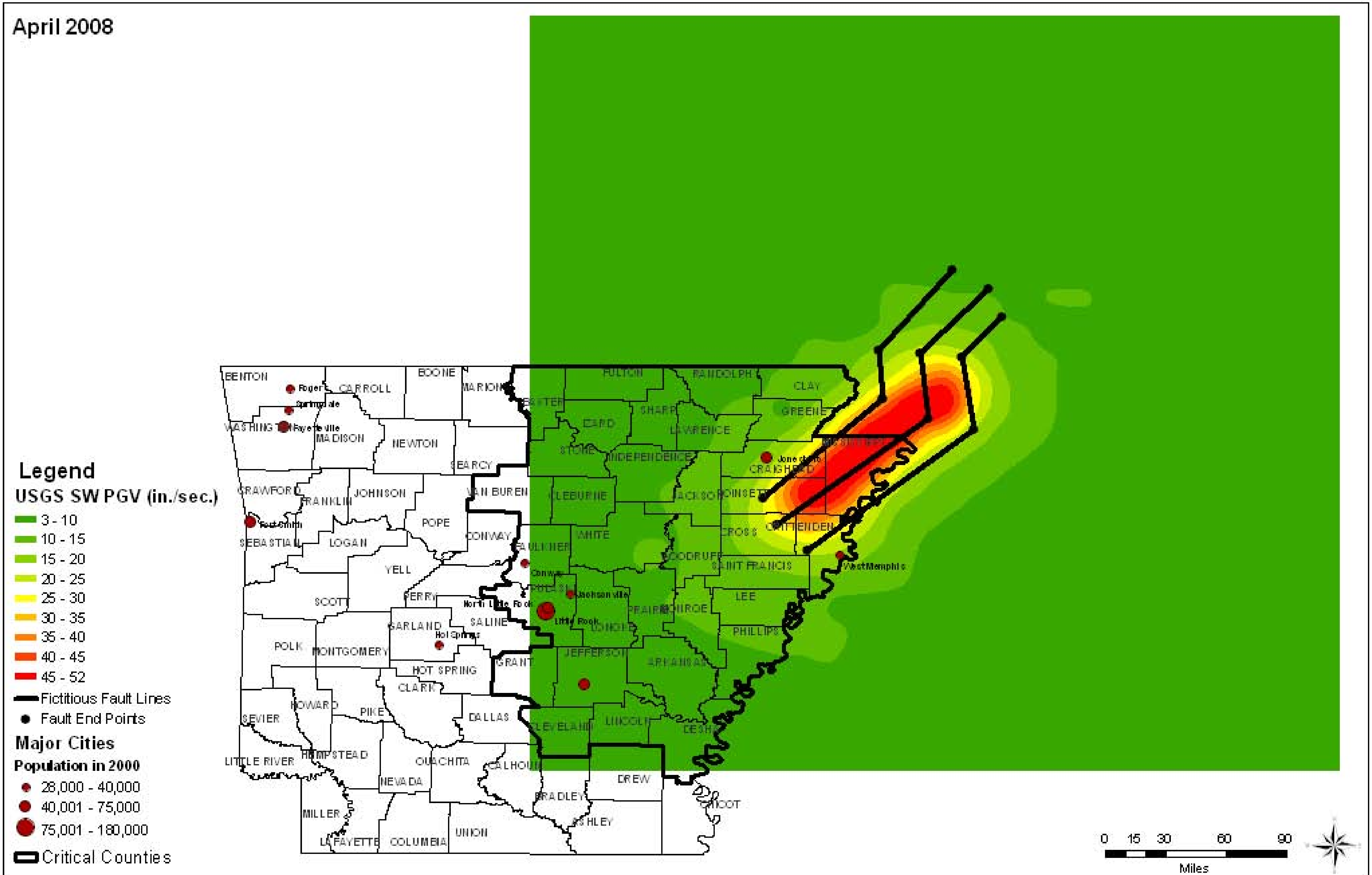
Arkansas PGV from USGS - New Madrid Seismic Zone: M7.7 Event



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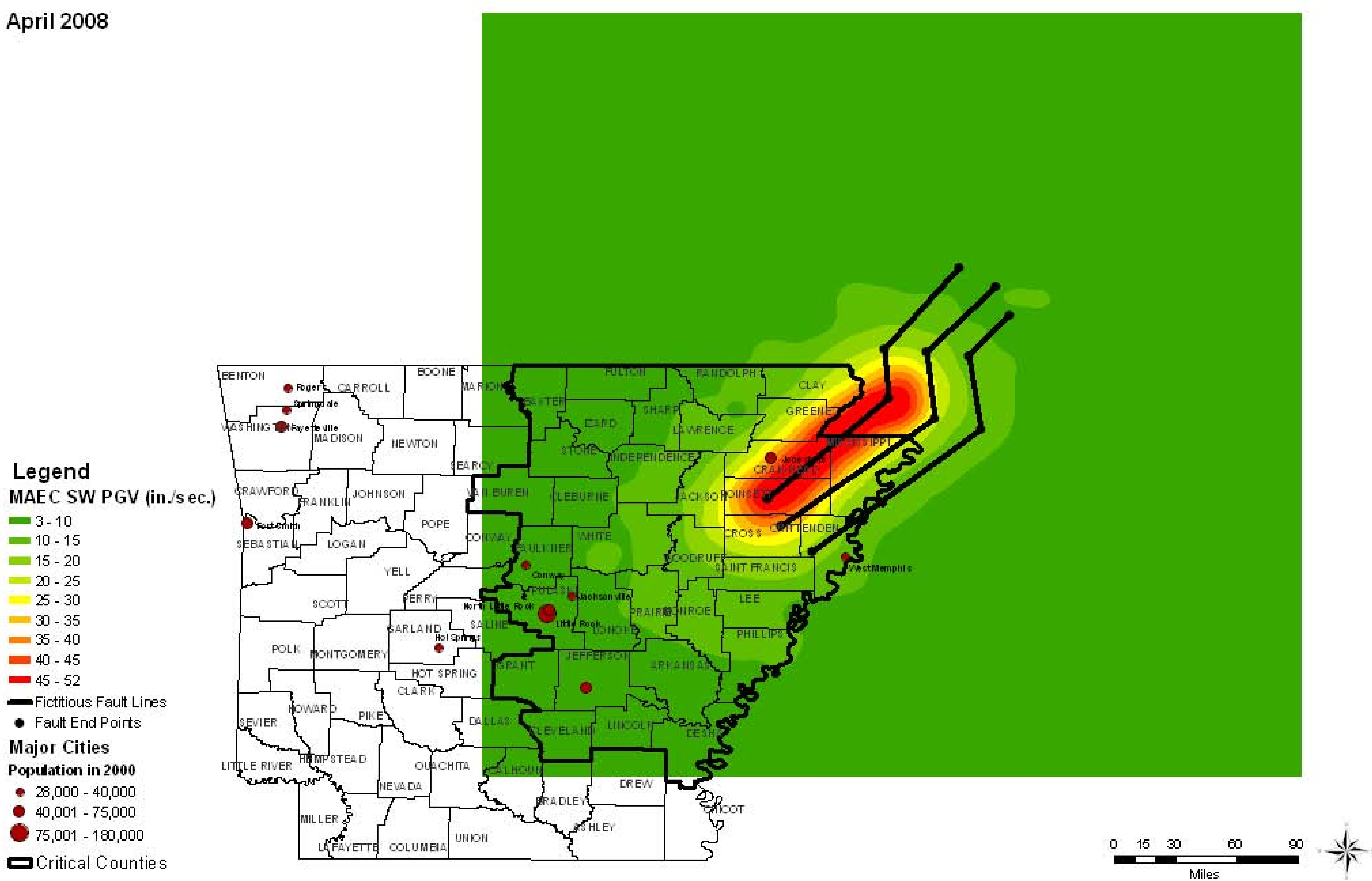
Arkansas PGV from MAEC - New Madrid Seismic Zone: M7.7 Event



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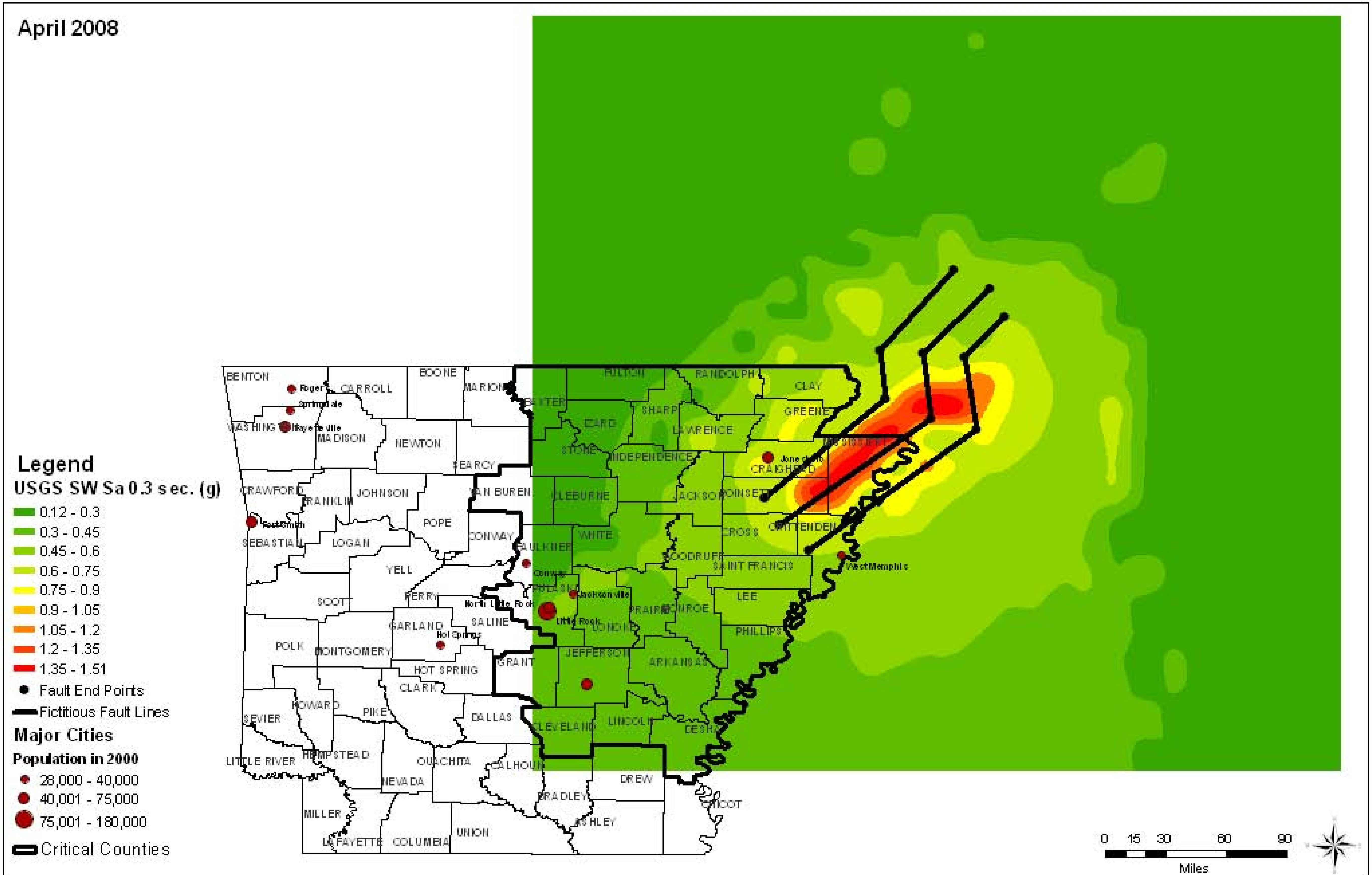
Arkansas Sa 0.3 sec. from USGS - New Madrid Seismic Zone: M7.7 Event



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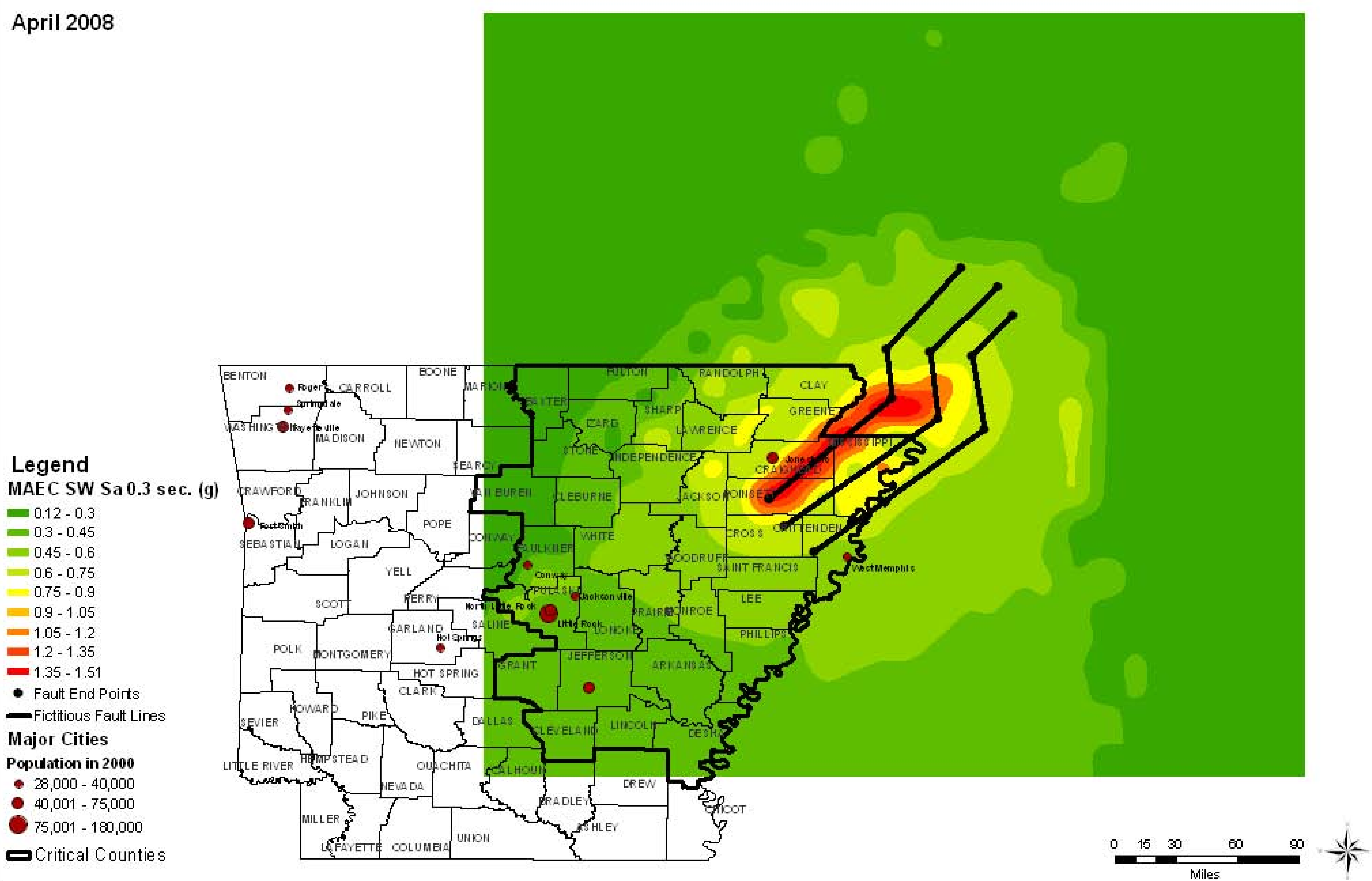
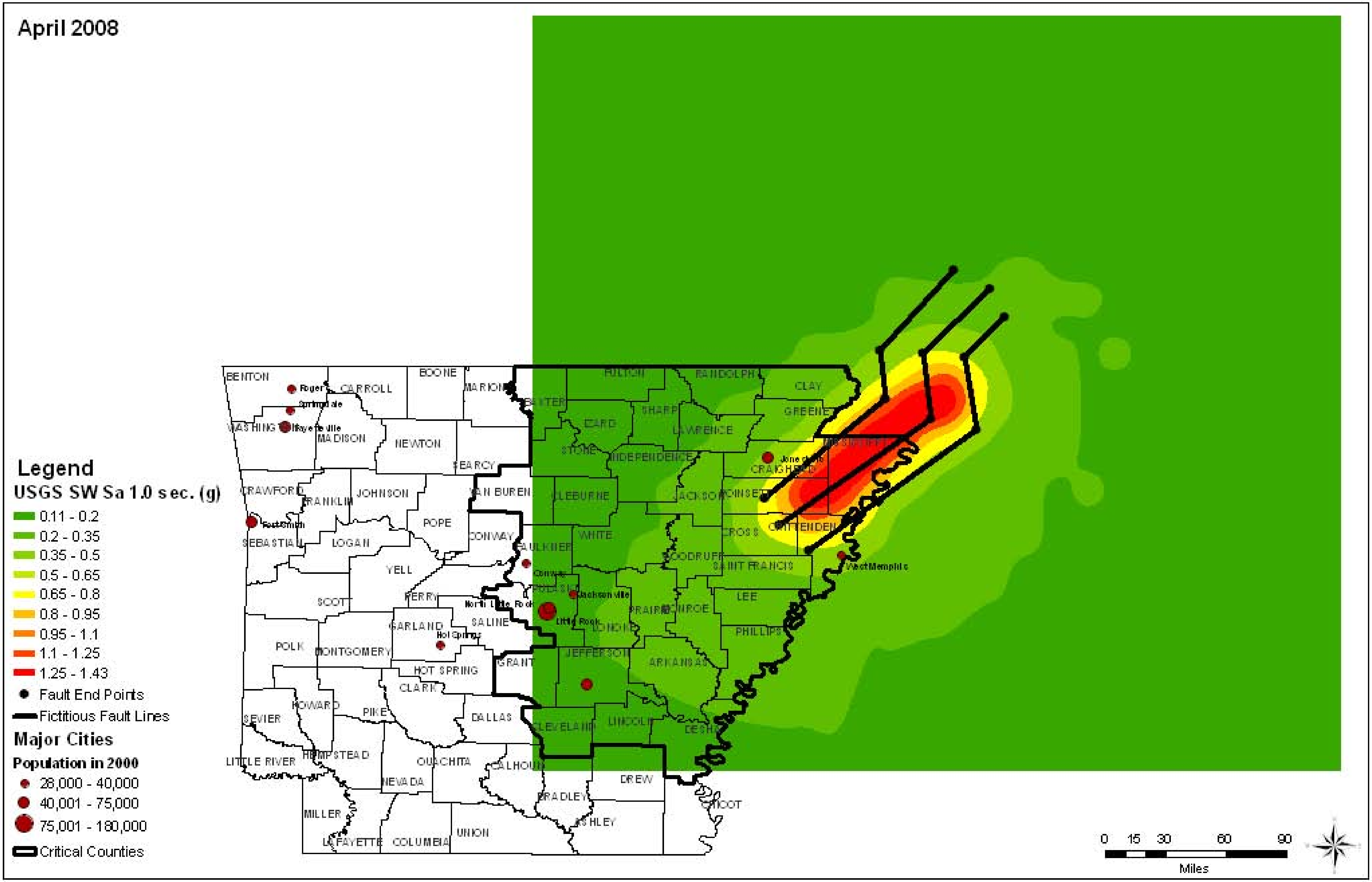


Arkansas Sa 1.0 sec. from USGS - New Madrid Seismic Zone: M7.7 Event



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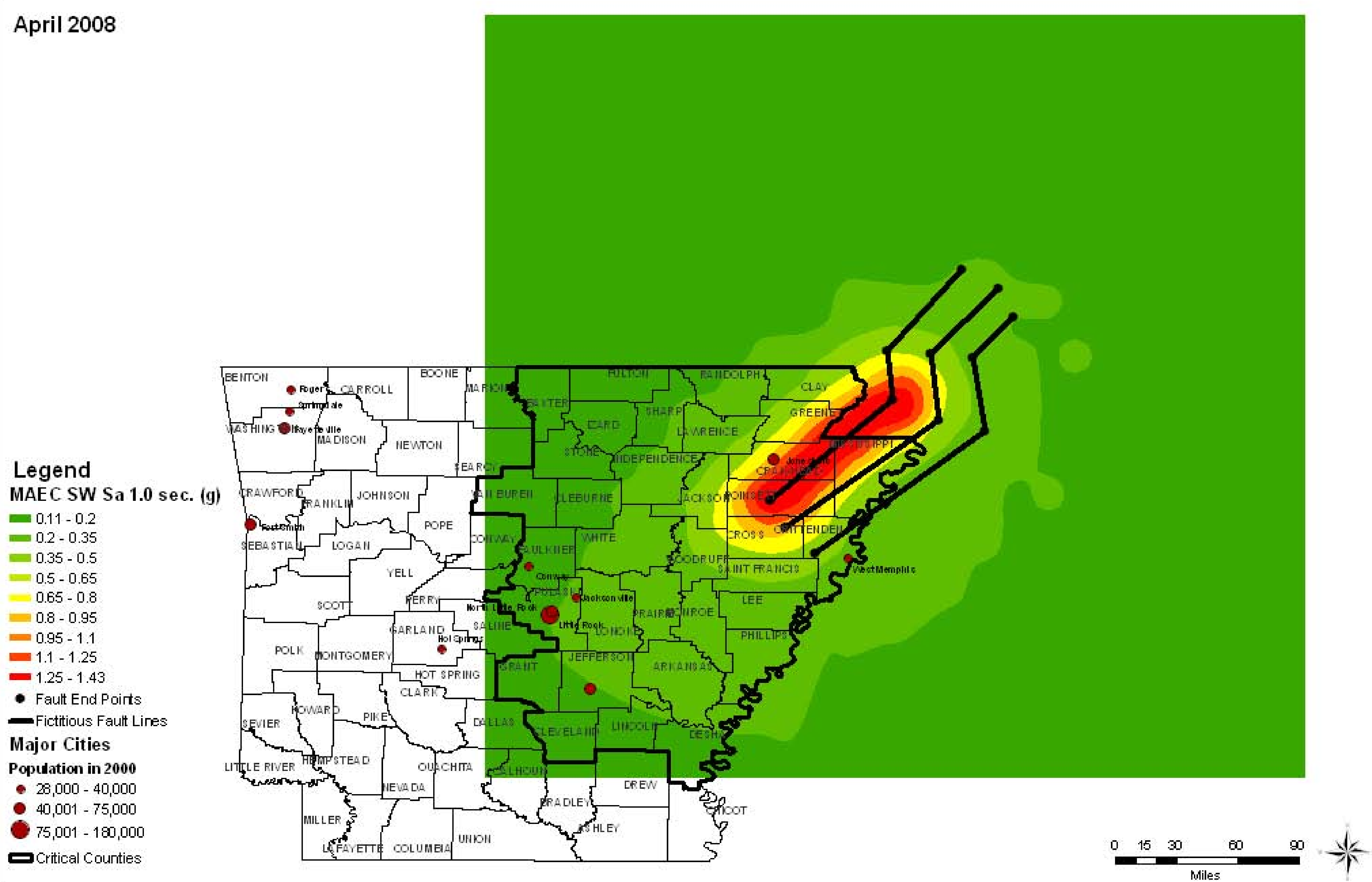

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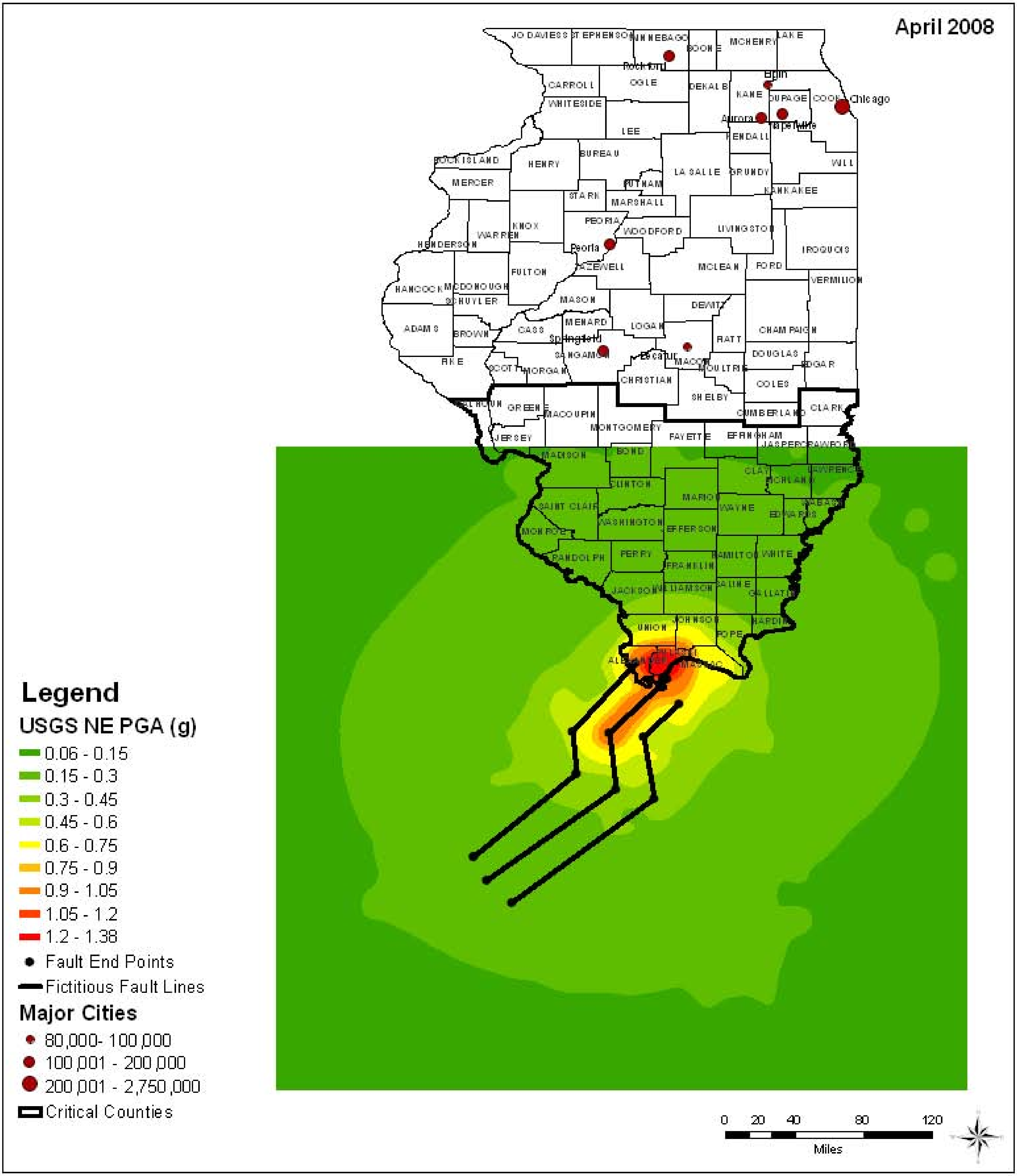
Illinois PGA from USGS - New Madrid Seismic Zone: M7.7 Event



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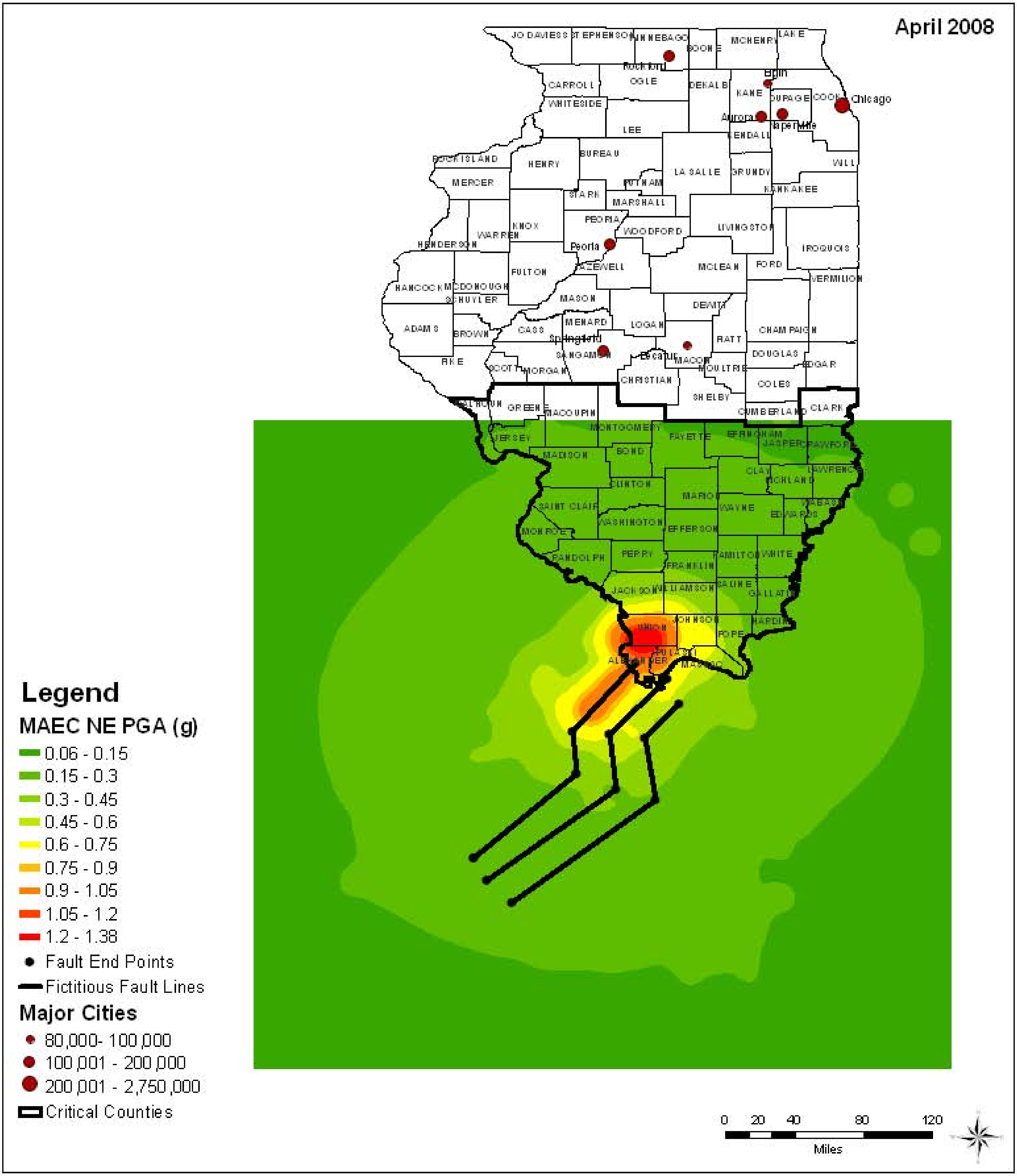
Theresa Jefferson, Principal Investigator

Illinois PGA from MAEC - New Madrid Seismic Zone: M7.7 Event



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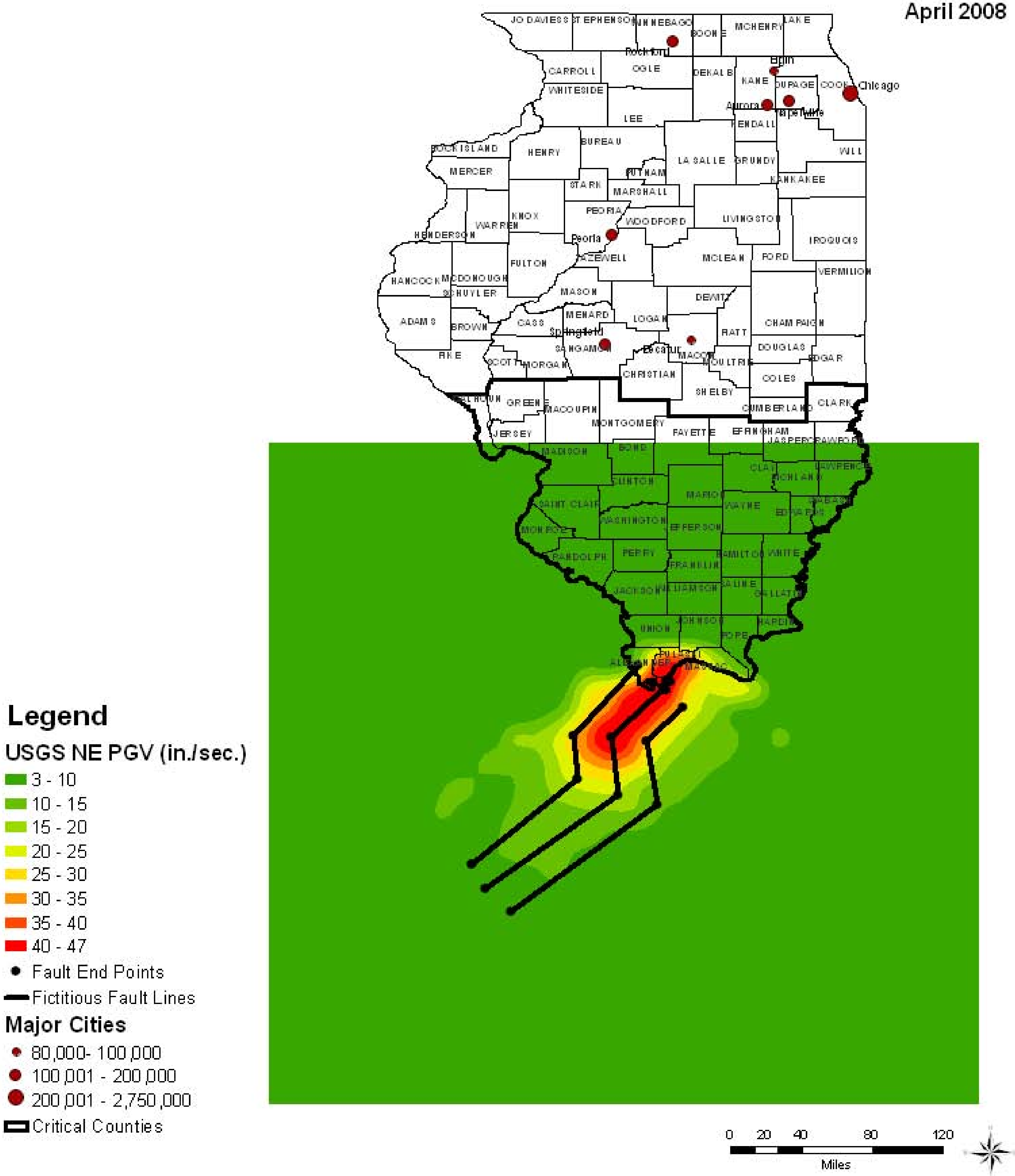
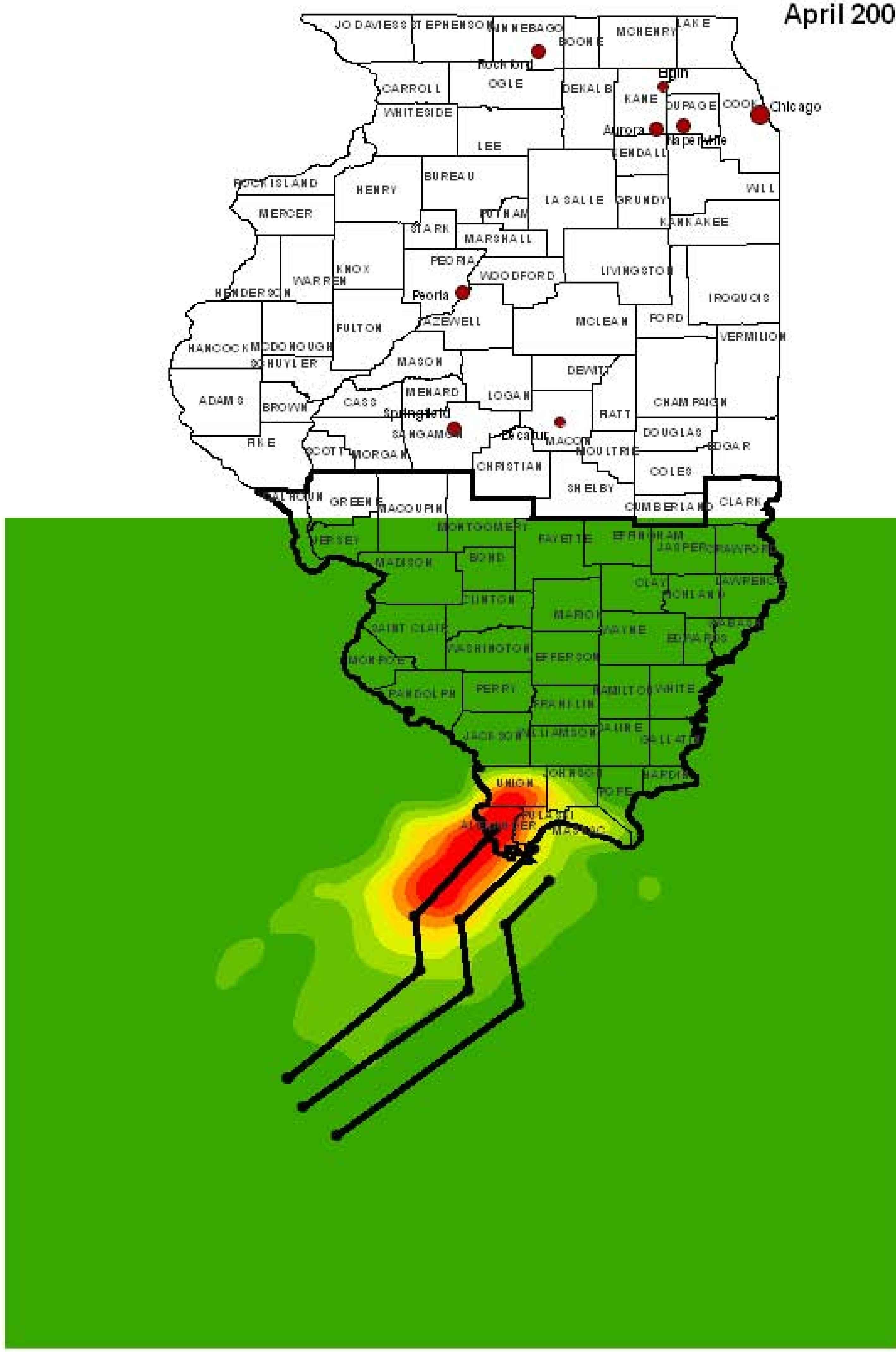
Illinois PGV from USGS - New Madrid Seismic Zone: M7.7 Event



Illinois PGV from MAEC - New Madrid Seismic Zone: M7.7 Event

April 2008



Legend

MAEC NE PGV (in./sec.)

- 3 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 47
- Fault End Points
- Fictitious Fault Lines

Major Cities

- 80,000- 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000
- Critical Counties

0 20 40 80 120
Miles

Mid-America Earthquake Center

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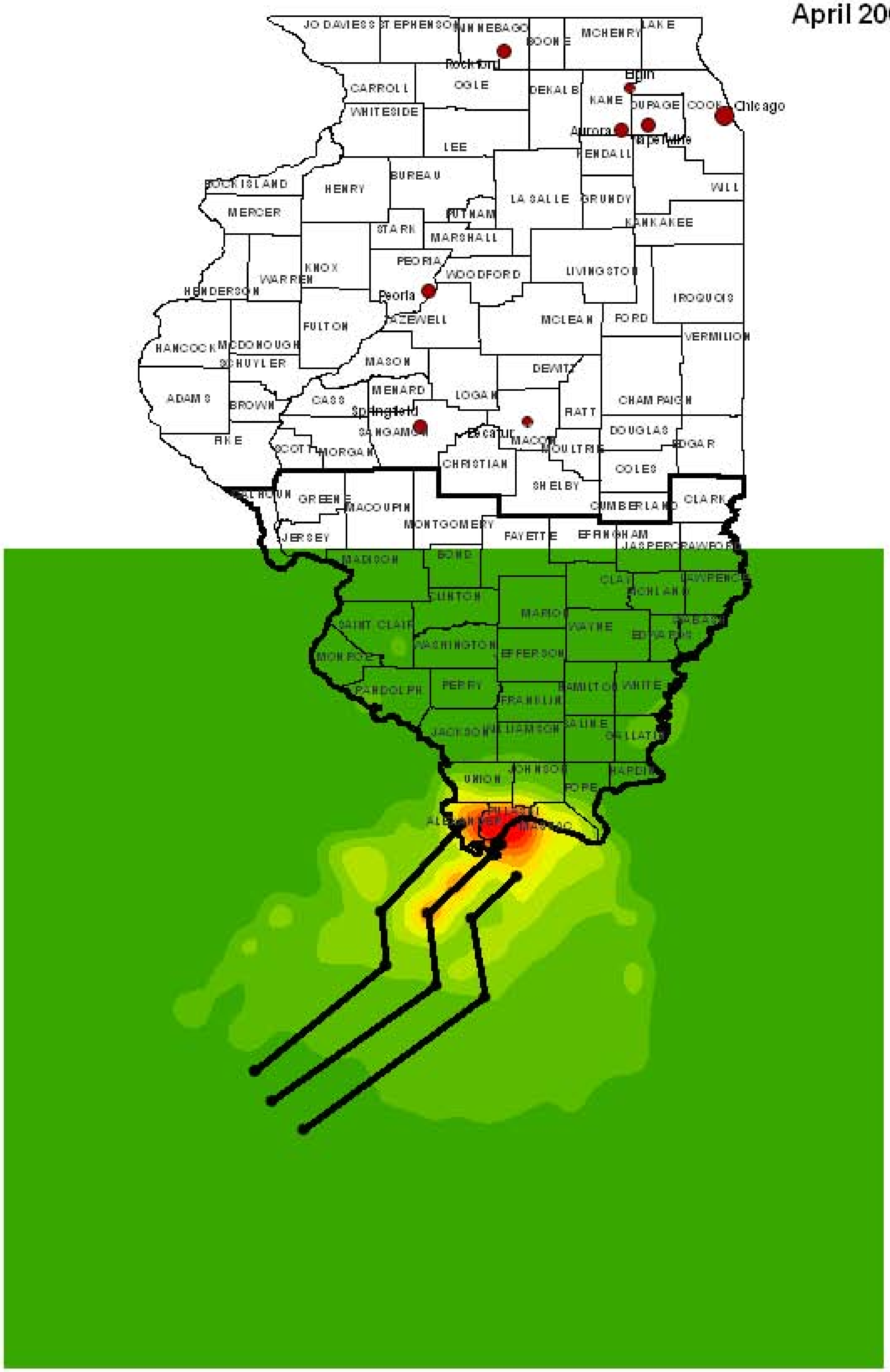
Illinois Sa 0.3 sec. from USGS - New Madrid Seismic Zone: M7.7 Event

April 2008



Legend

USGS NE Sa 0.3 Sec.(g)

- 0.12 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- 1.2 - 1.4
- 1.4 - 1.6
- 1.6 - 1.8
- 1.8 - 2.0
- 2.0 - 2.24
- Fault End Points
- Fictitious Fault Lines

Major Cities

- 80,000- 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000
- Critical Counties

0 20 40 80 120
Miles

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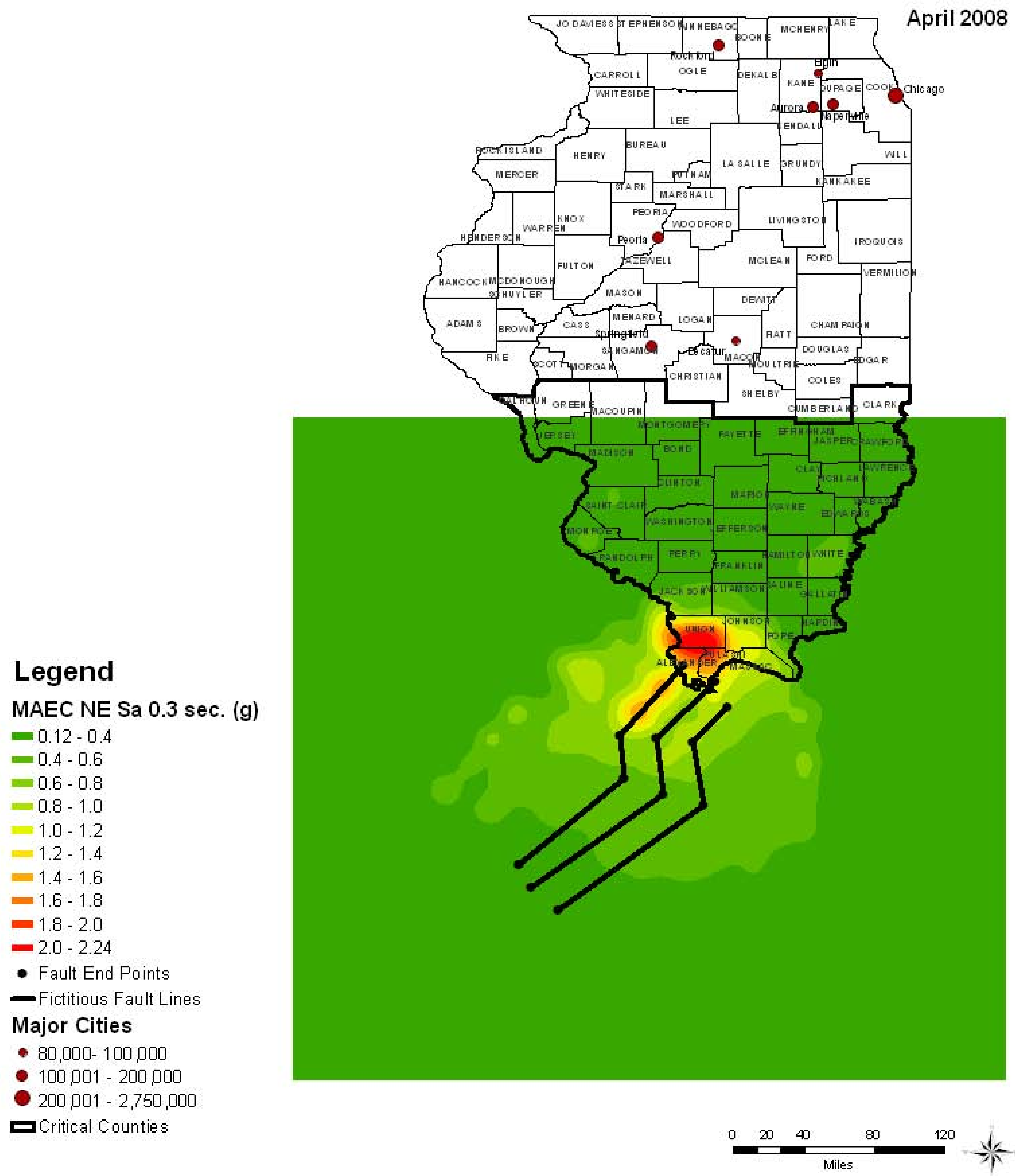

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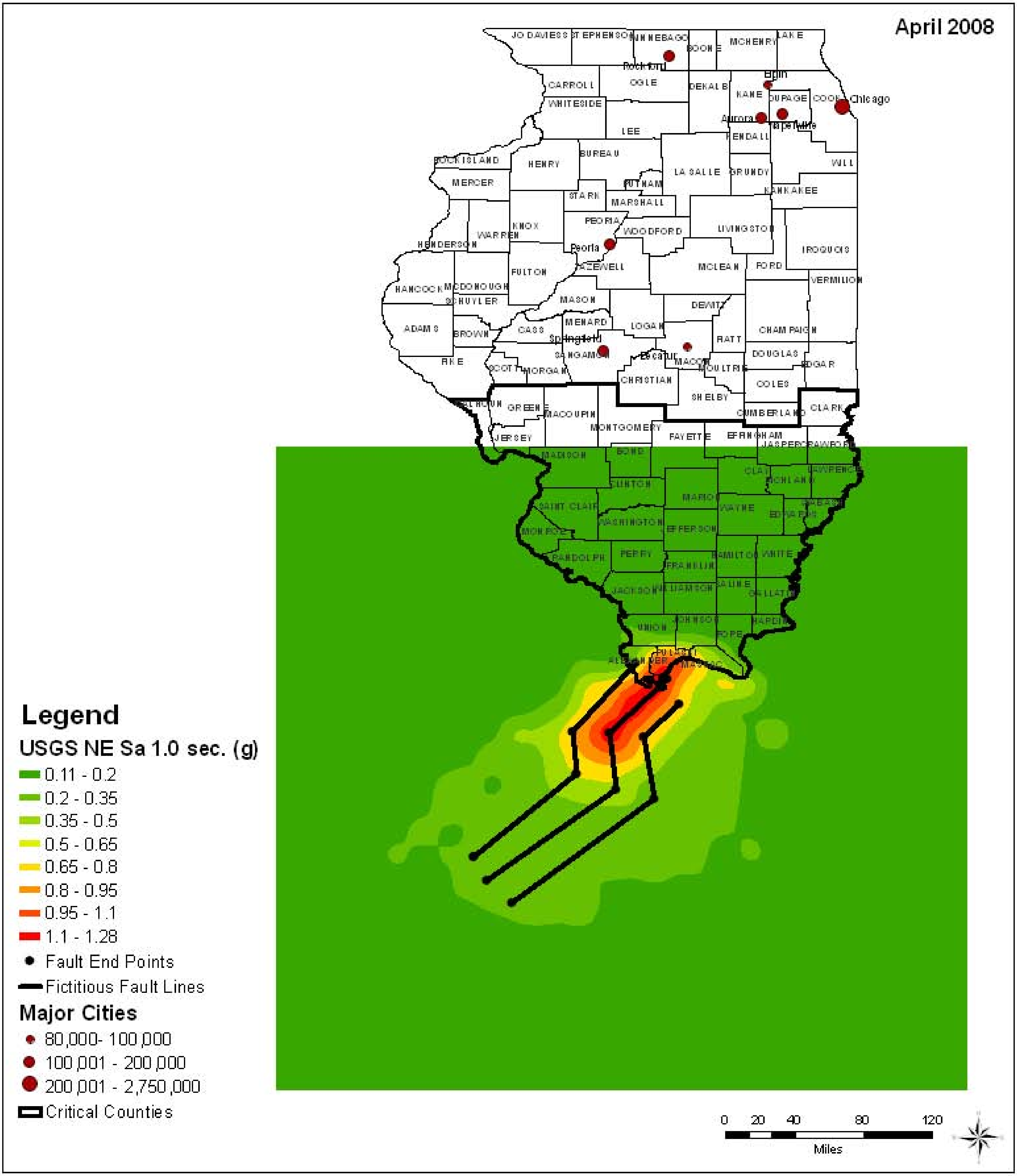

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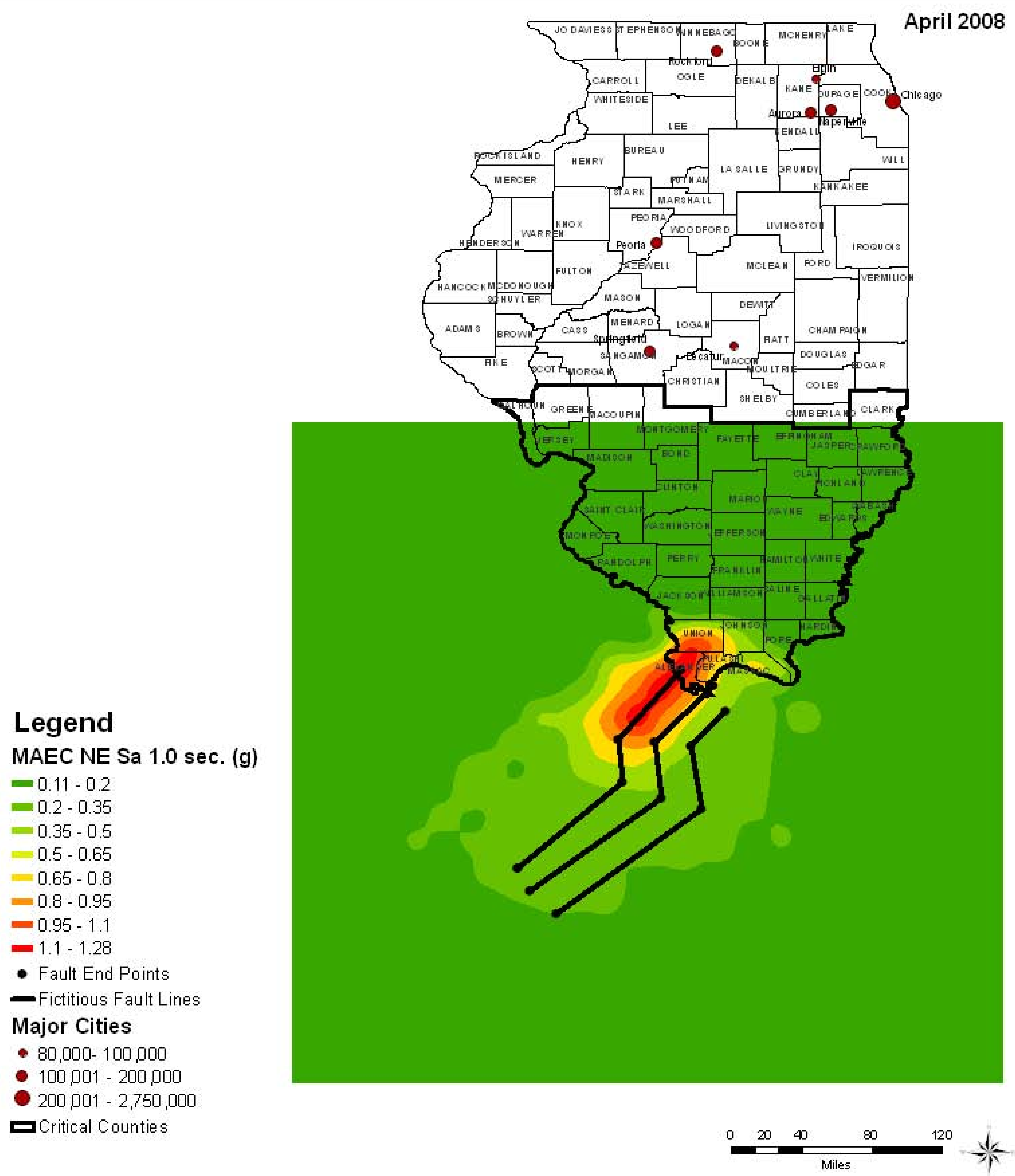
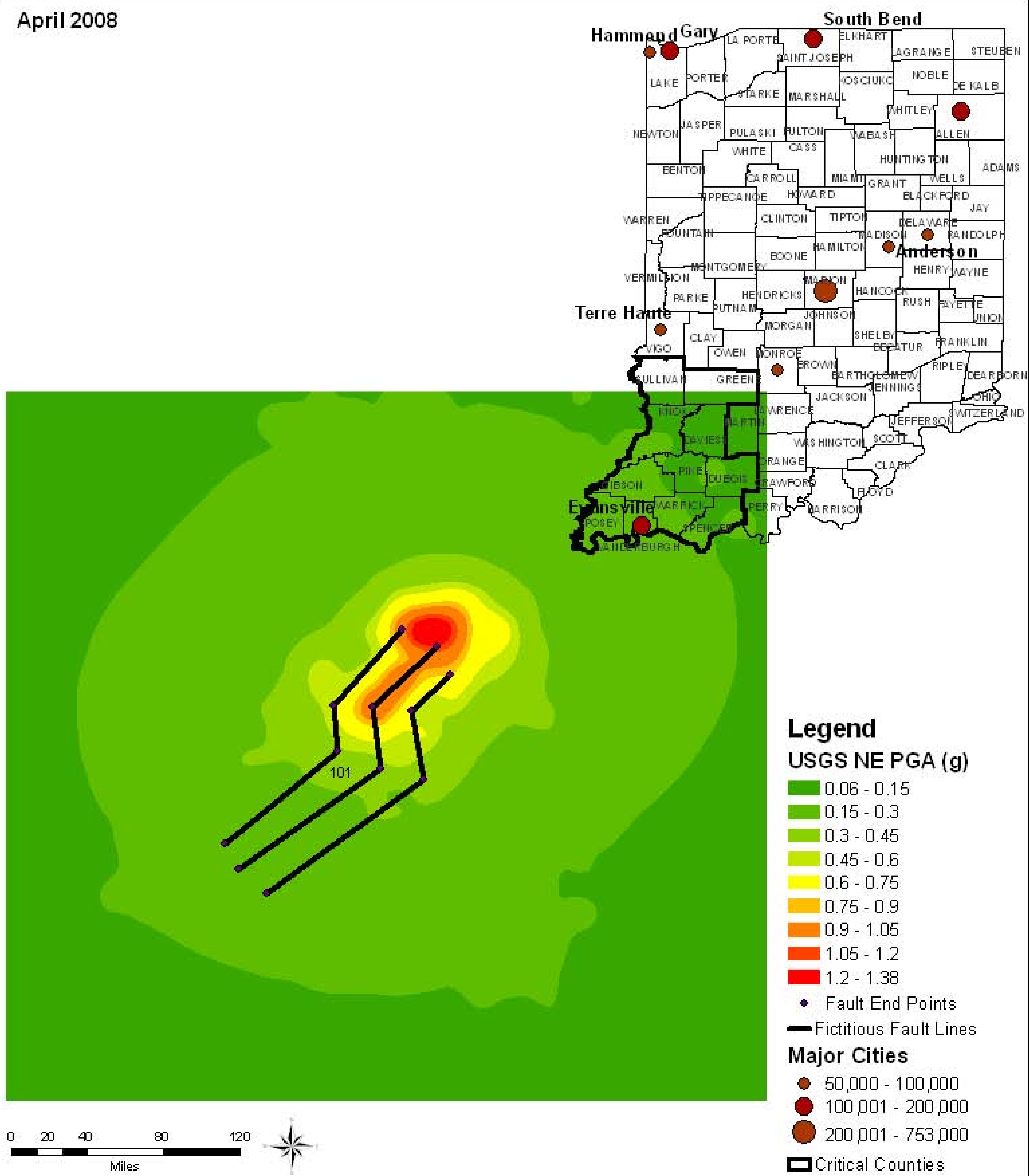


Indiana PGA for USGS - New Madrid Seismic Zone: M7.7 Event



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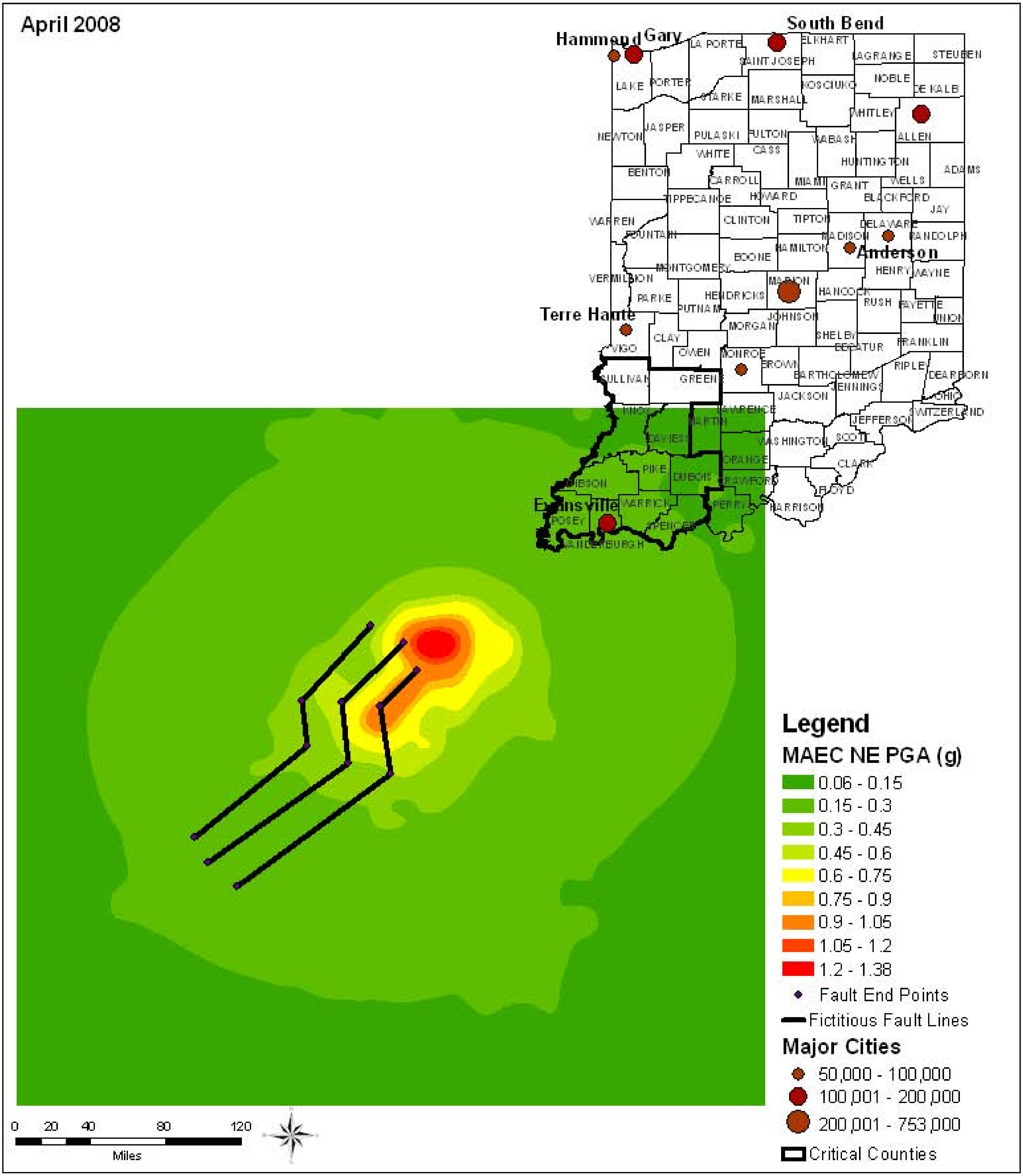

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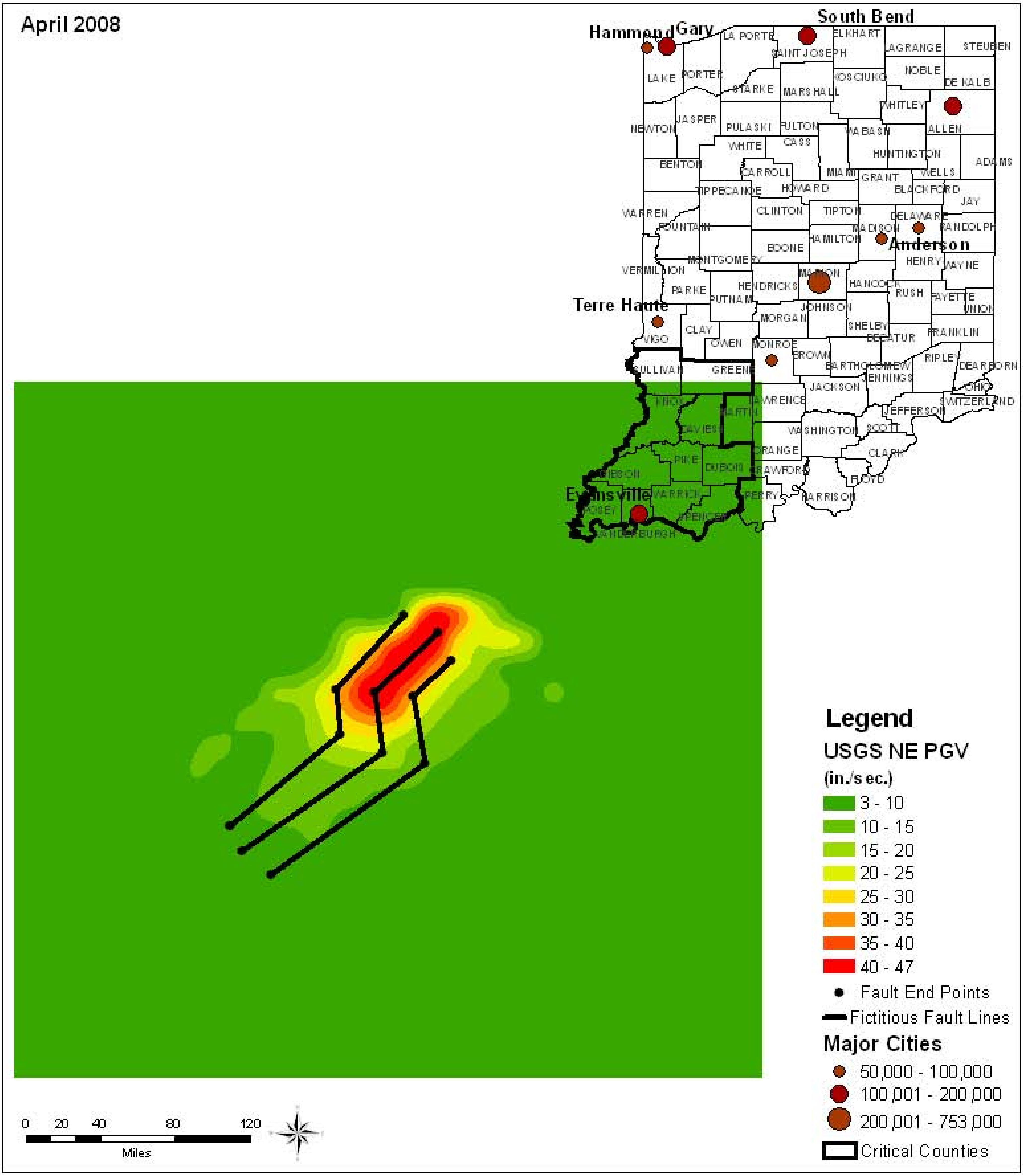
Indiana PGV from USGS - New Madrid Seismic Zone: M7.7 Event



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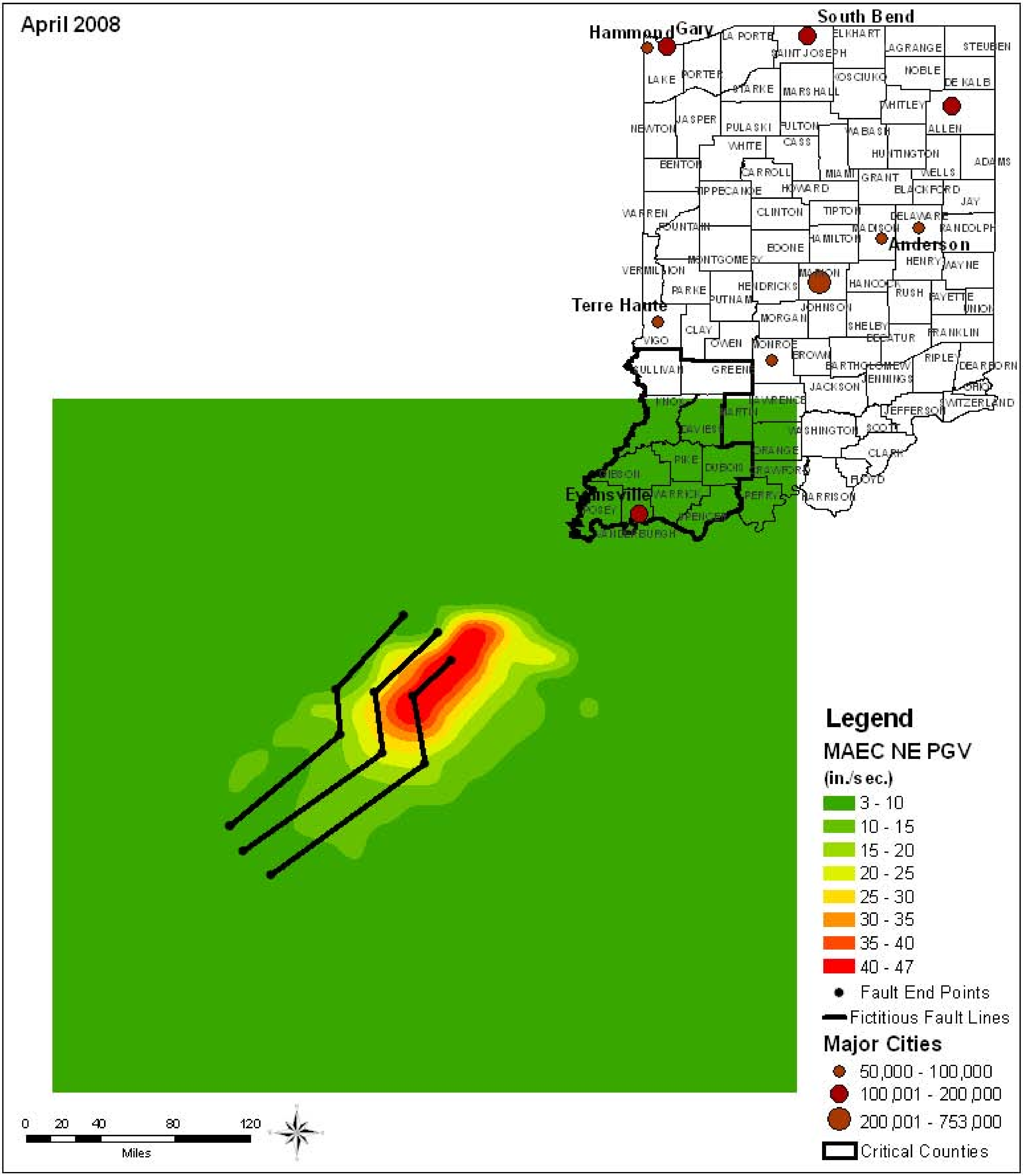

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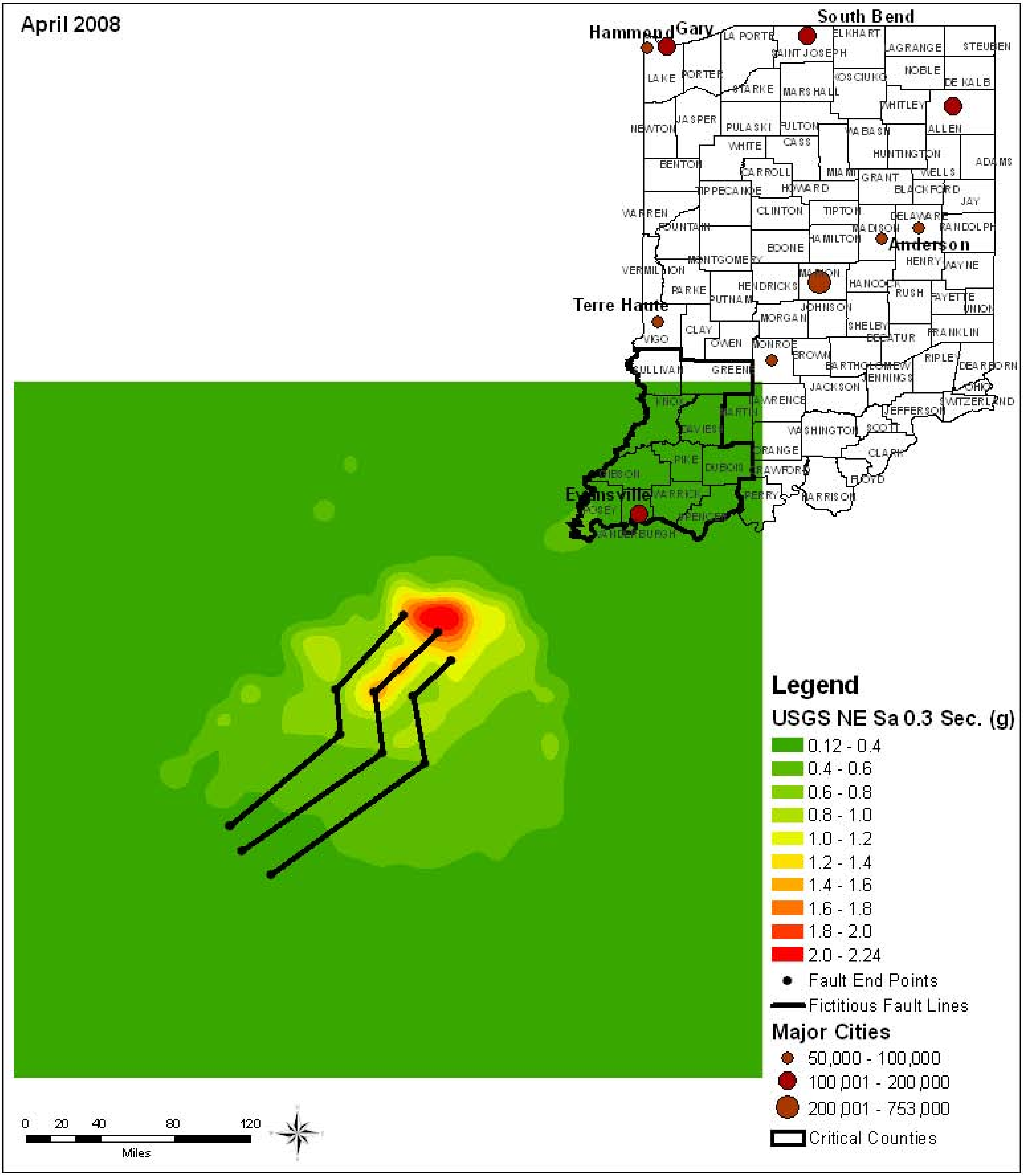

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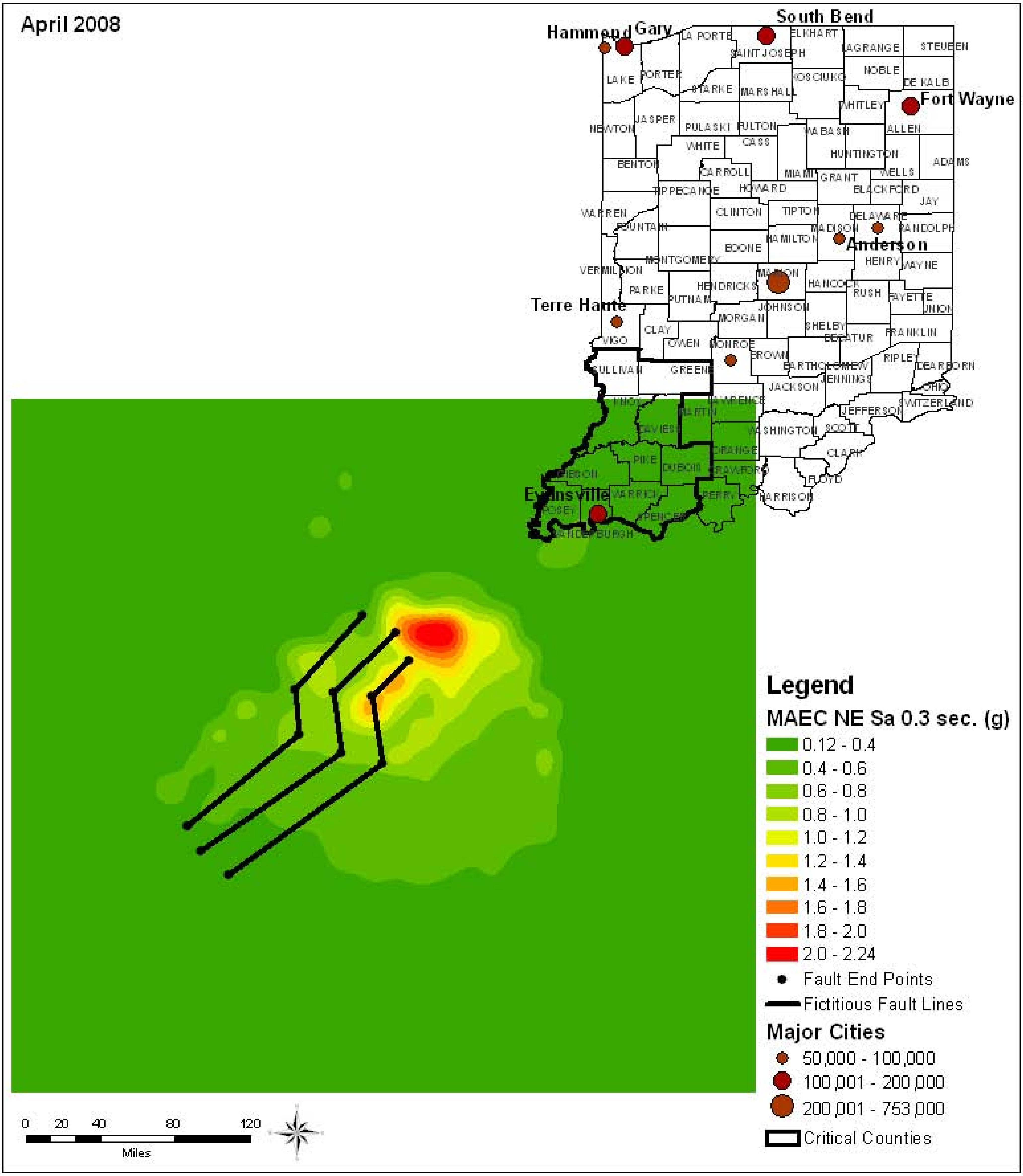

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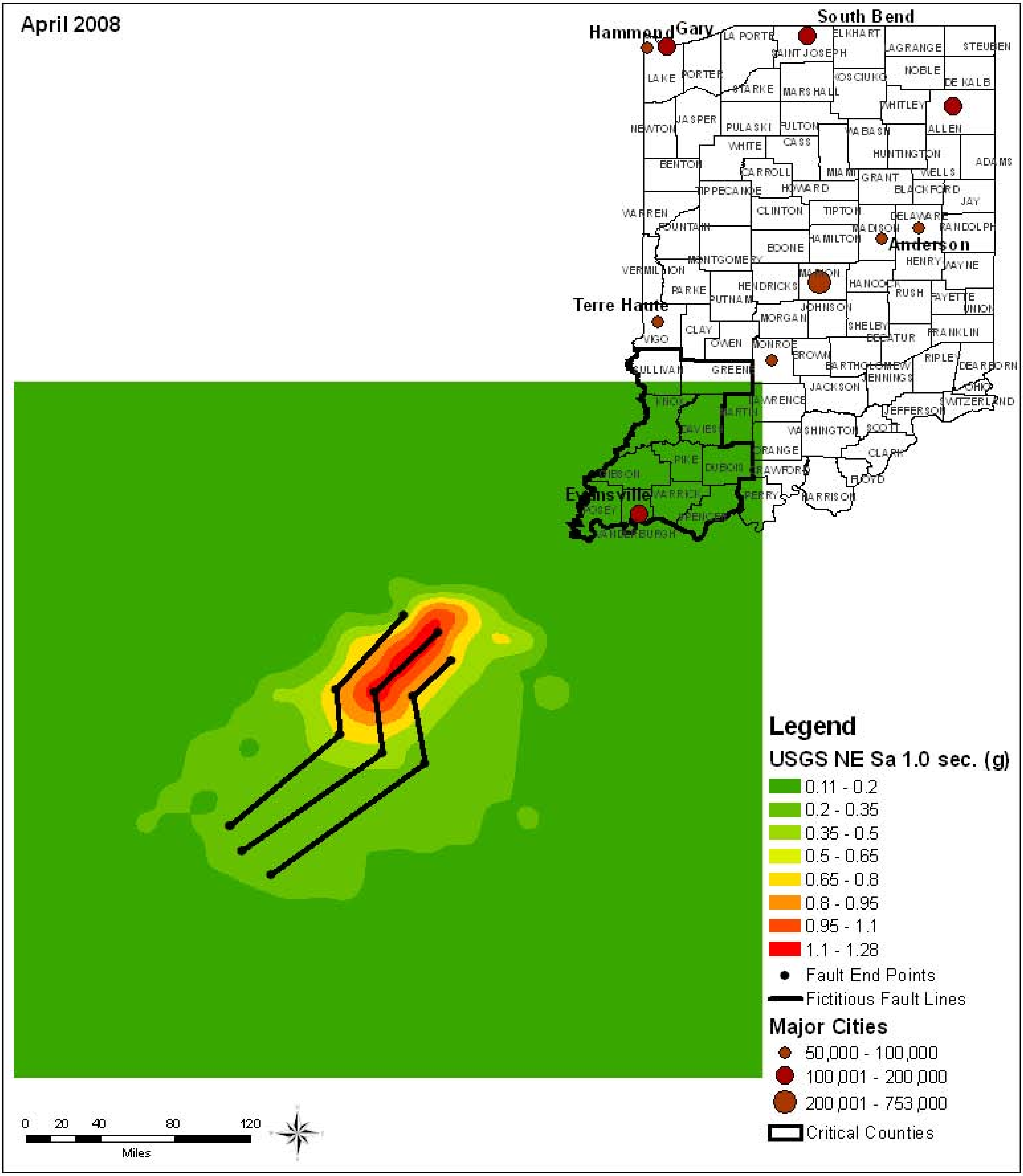
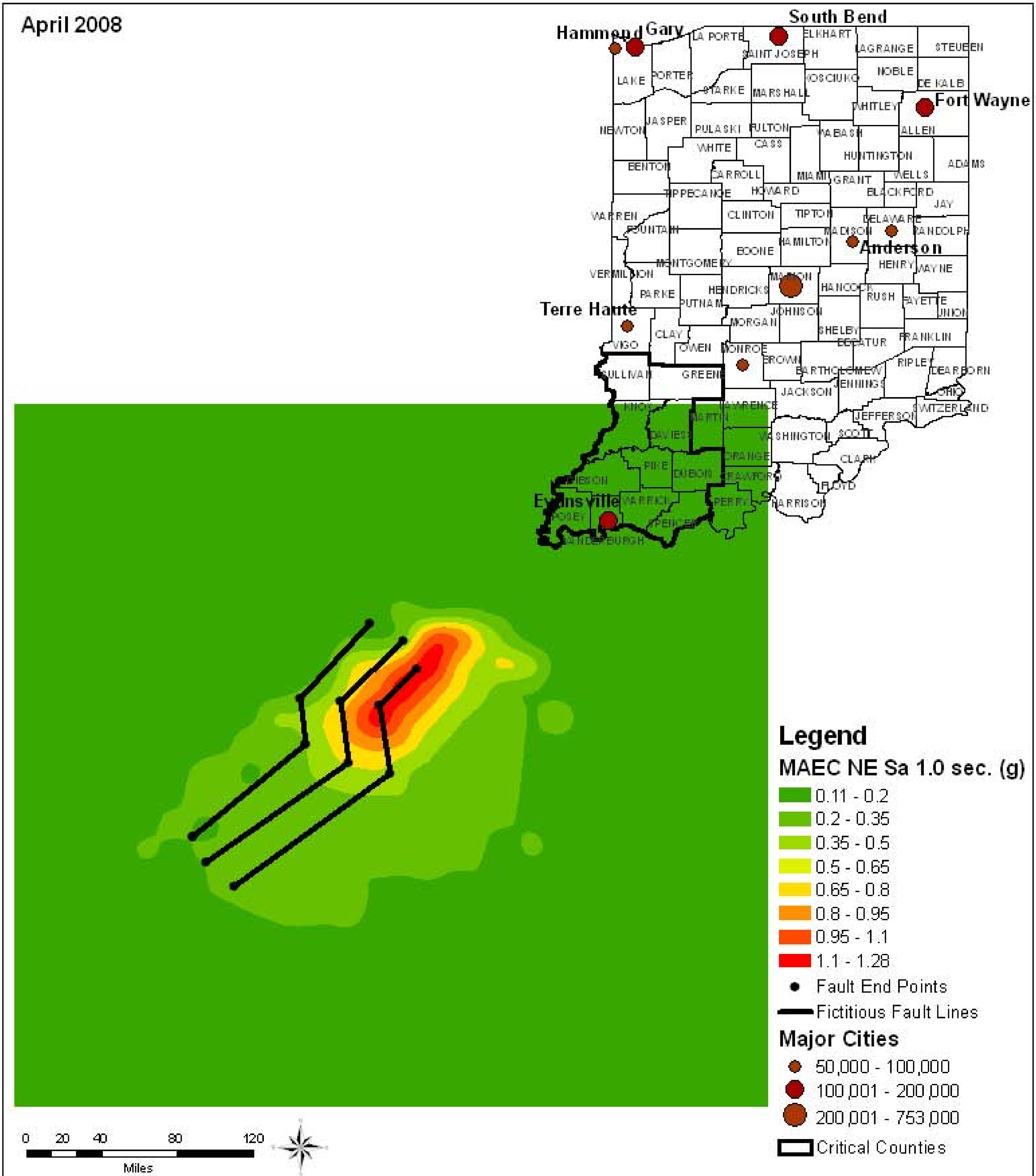


Indiana Sa 1.0 sec. from MAEC - New Madrid Seismic Zone: M7.7 Event

April 2008



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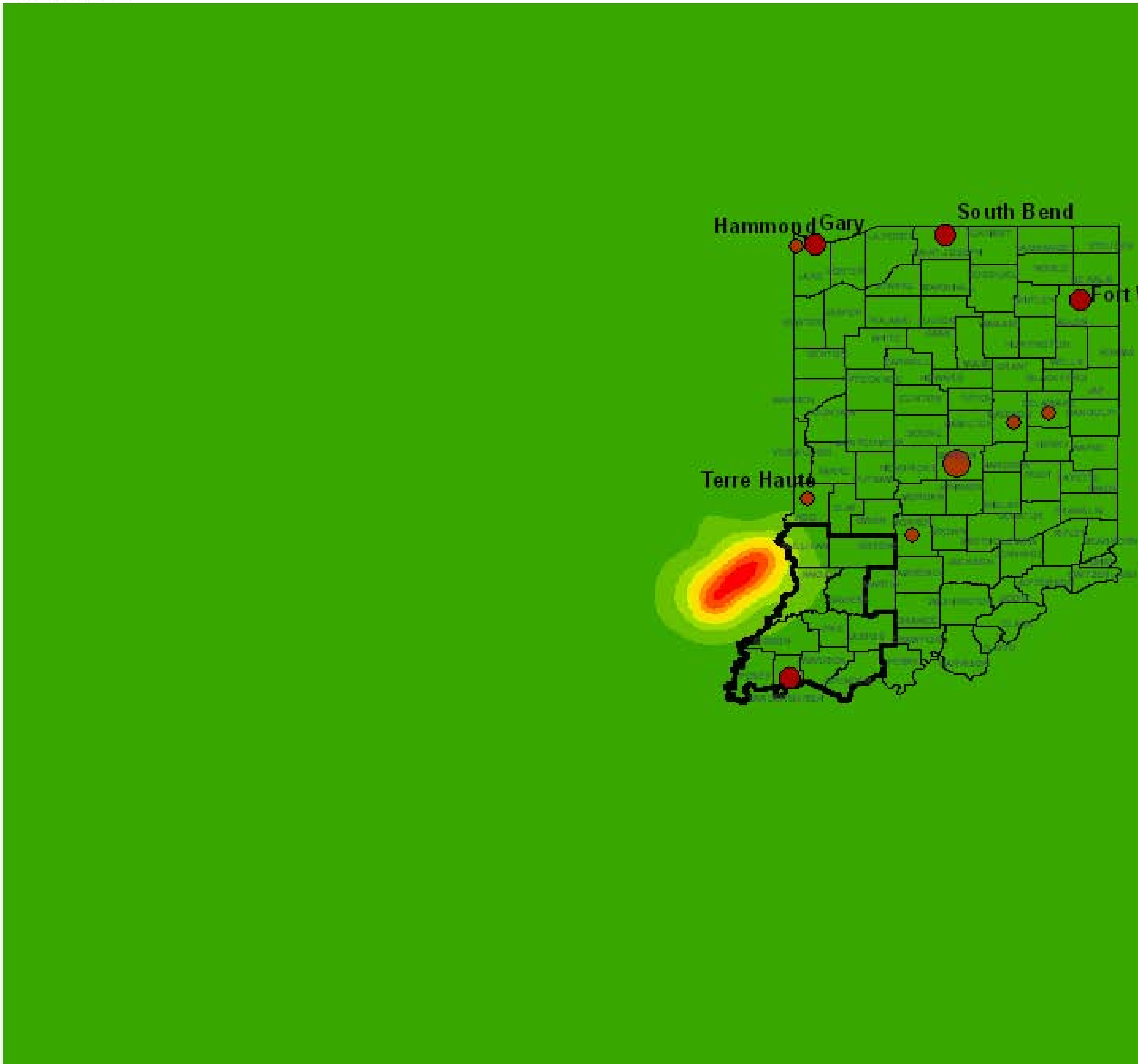
Indiana PGA - Wabash Valley Seismic Zone: M7.1 Event

April 2008



Legend

USGS Wabash PGA (g)

- 0.05 - 0.25
- 0.25 - 0.45
- 0.45 - 0.65
- 0.65 - 0.85
- 0.85 - 1.05
- 1.05 - 1.25
- 1.25 - 1.45
- 1.45 - 1.65

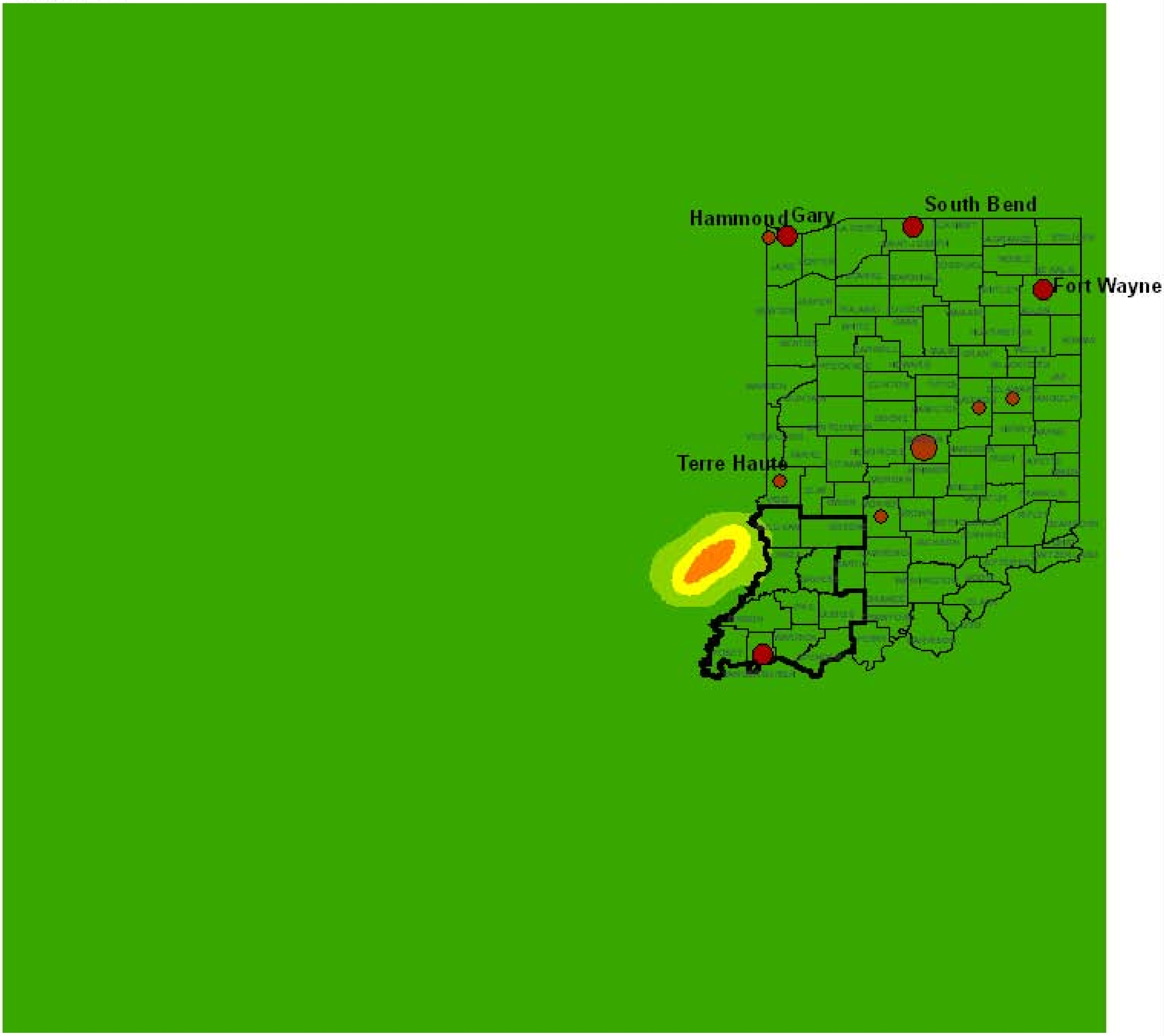
Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000
- Critical Counties

0 25 50 100 150
Miles

Indiana PGV - Wabash Valley Seismic Zone: M7.1 Event

April 2008



Legend

USGS Wabash PGV (in./sec.)
- 2.5 - 5
- 5 - 10
- 10- 15
- 15 - 20
- 20 - 22.5

Major Cities
- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000
- Critical Counties

0 25 50 100 150
Miles

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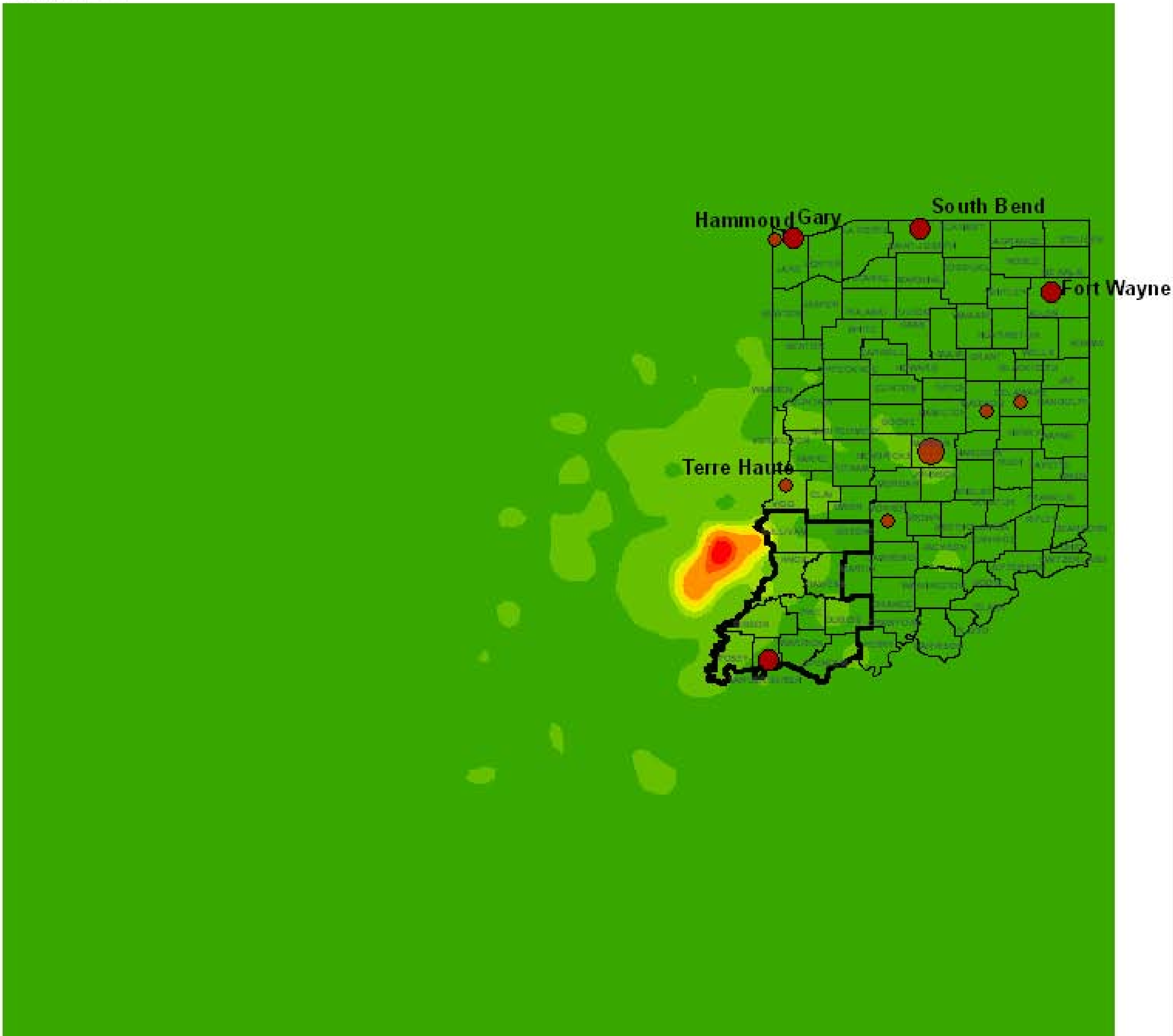
Indiana Sa 0.3 sec. - Wabash Valley Seismic Zone: M7.1 Event

April 2008



Legend

USGS Wabash Sa 0.3 sec. (g)

- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2.1

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000
- Critical Counties

0 25 50 100 150

Miles

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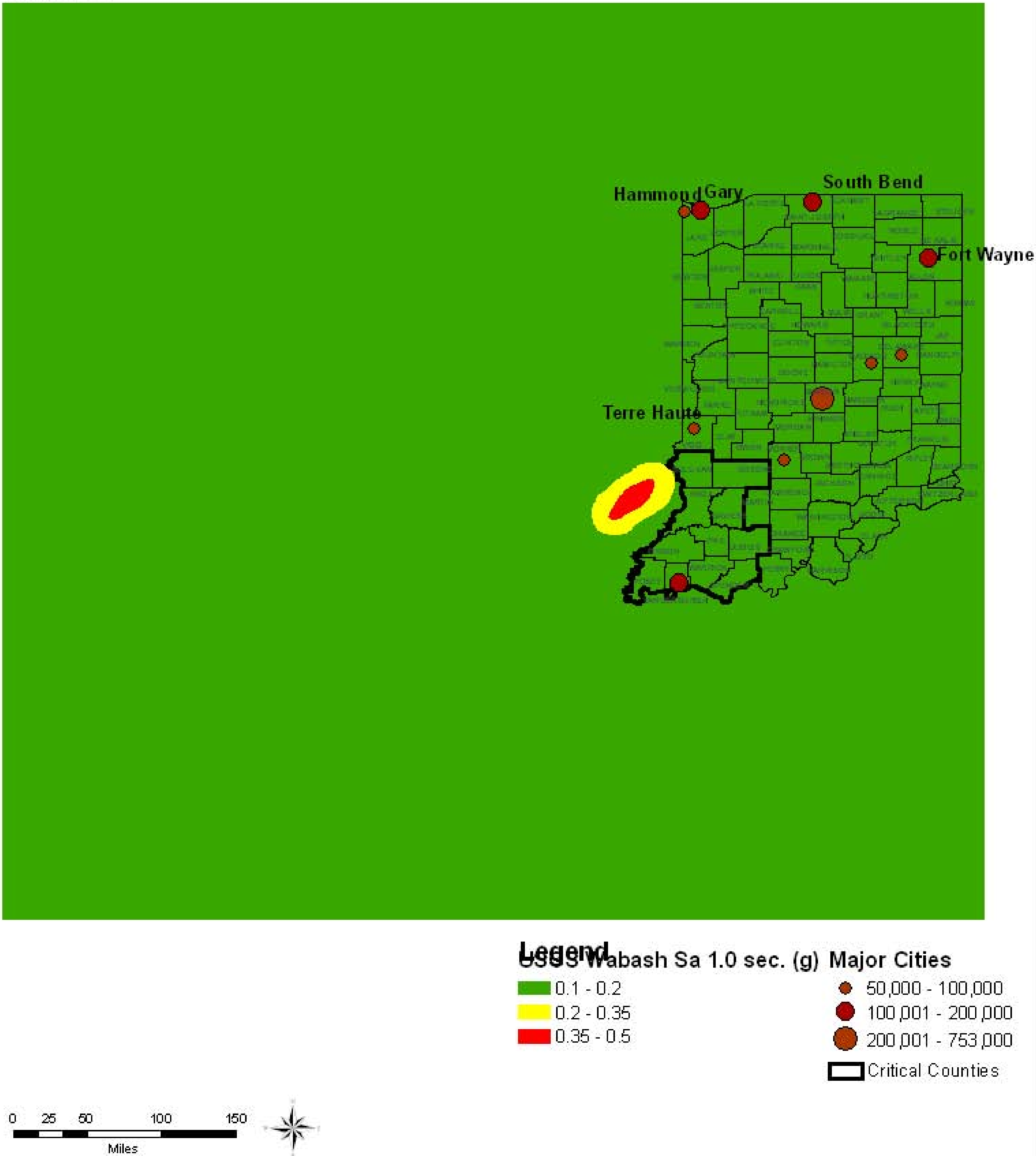
Indiana Sa 1.0 sec. - Wabash Valley Seismic Zone: M7.1 Event

April 2008



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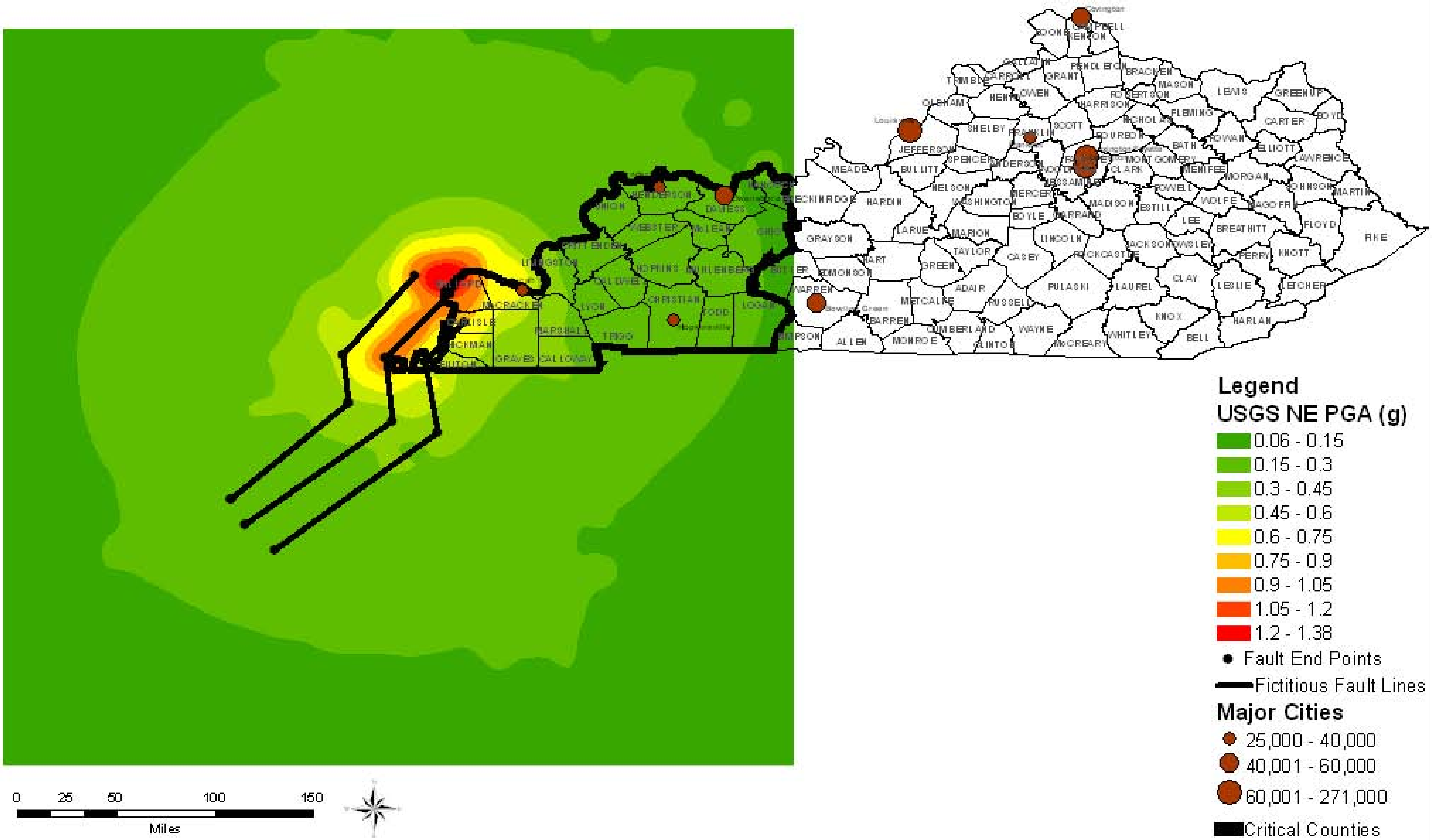
Kentucky PGA from USGS - New Madrid Seismic Zone: M7.7 Event

April 2008



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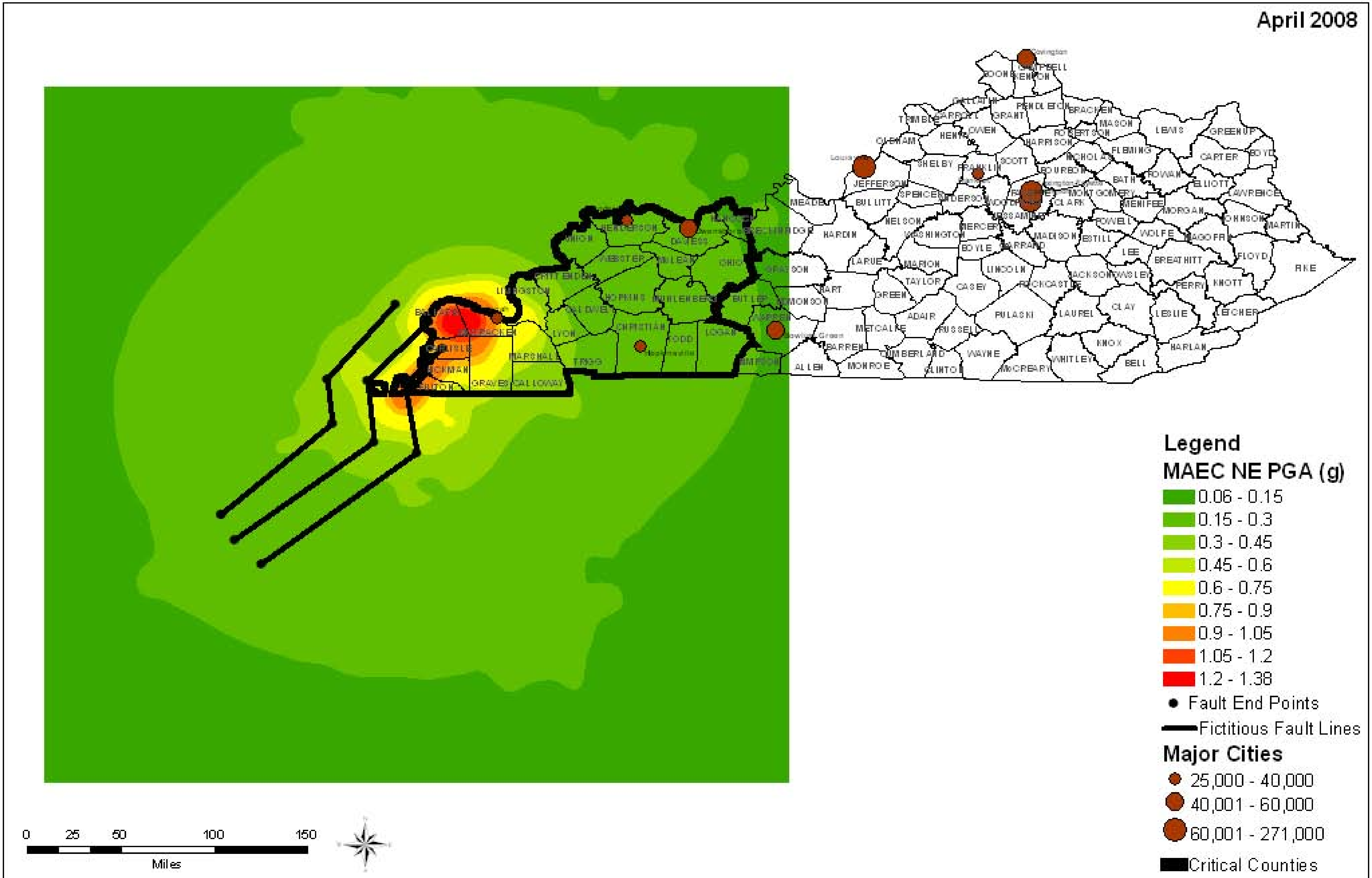
Kentucky PGA from MAEC - New Madrid Seismic Zone: M7.7 Event



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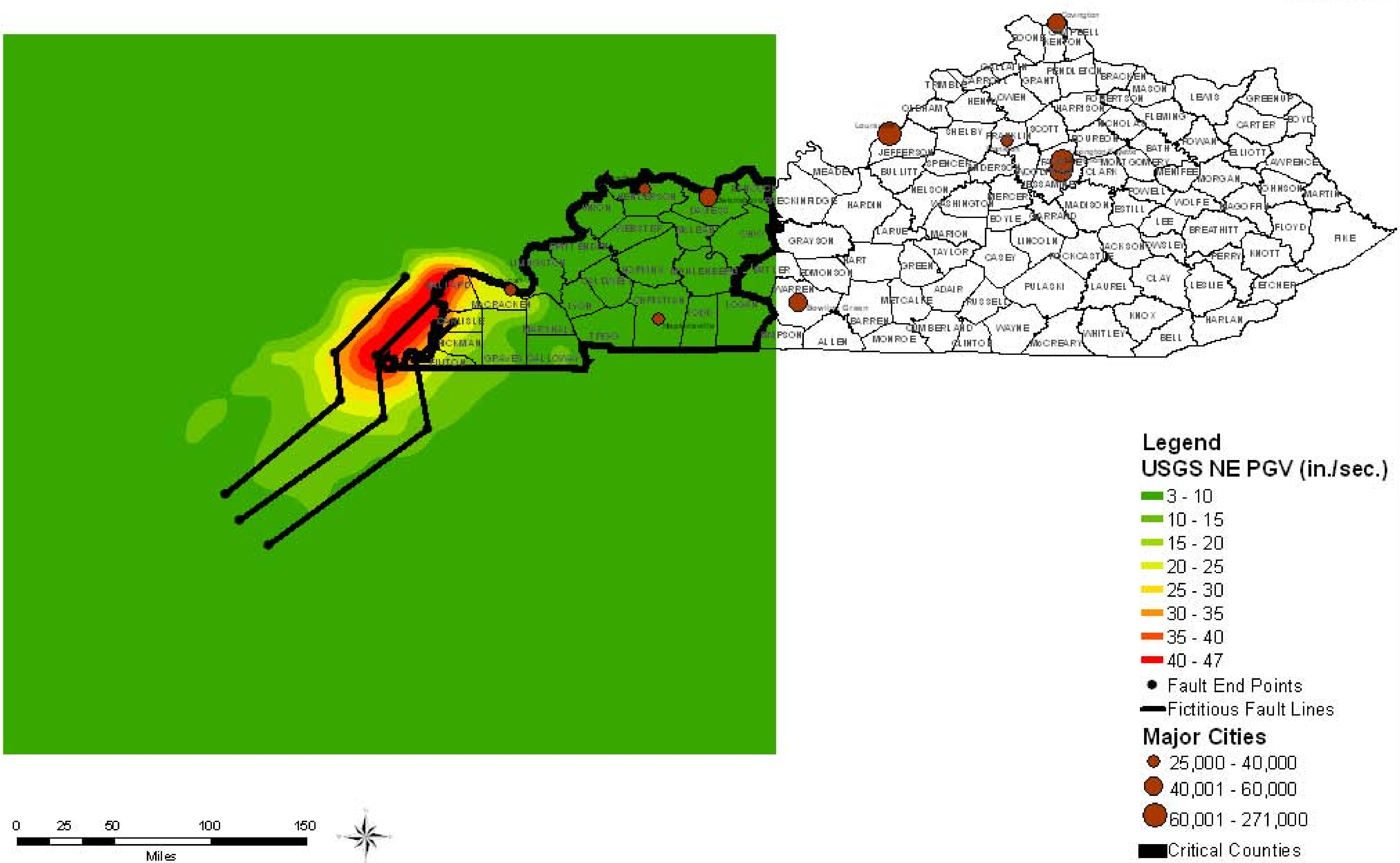

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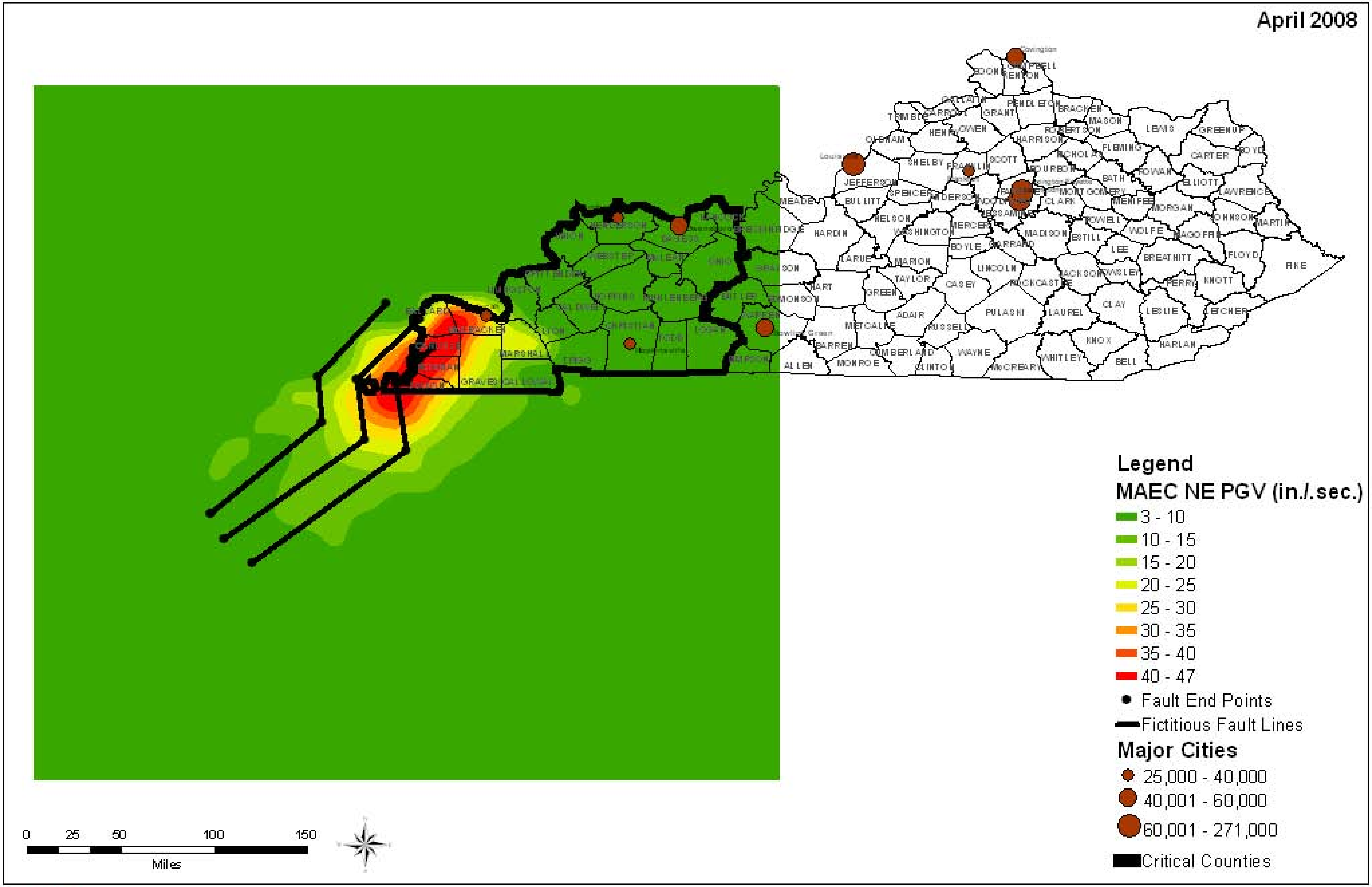

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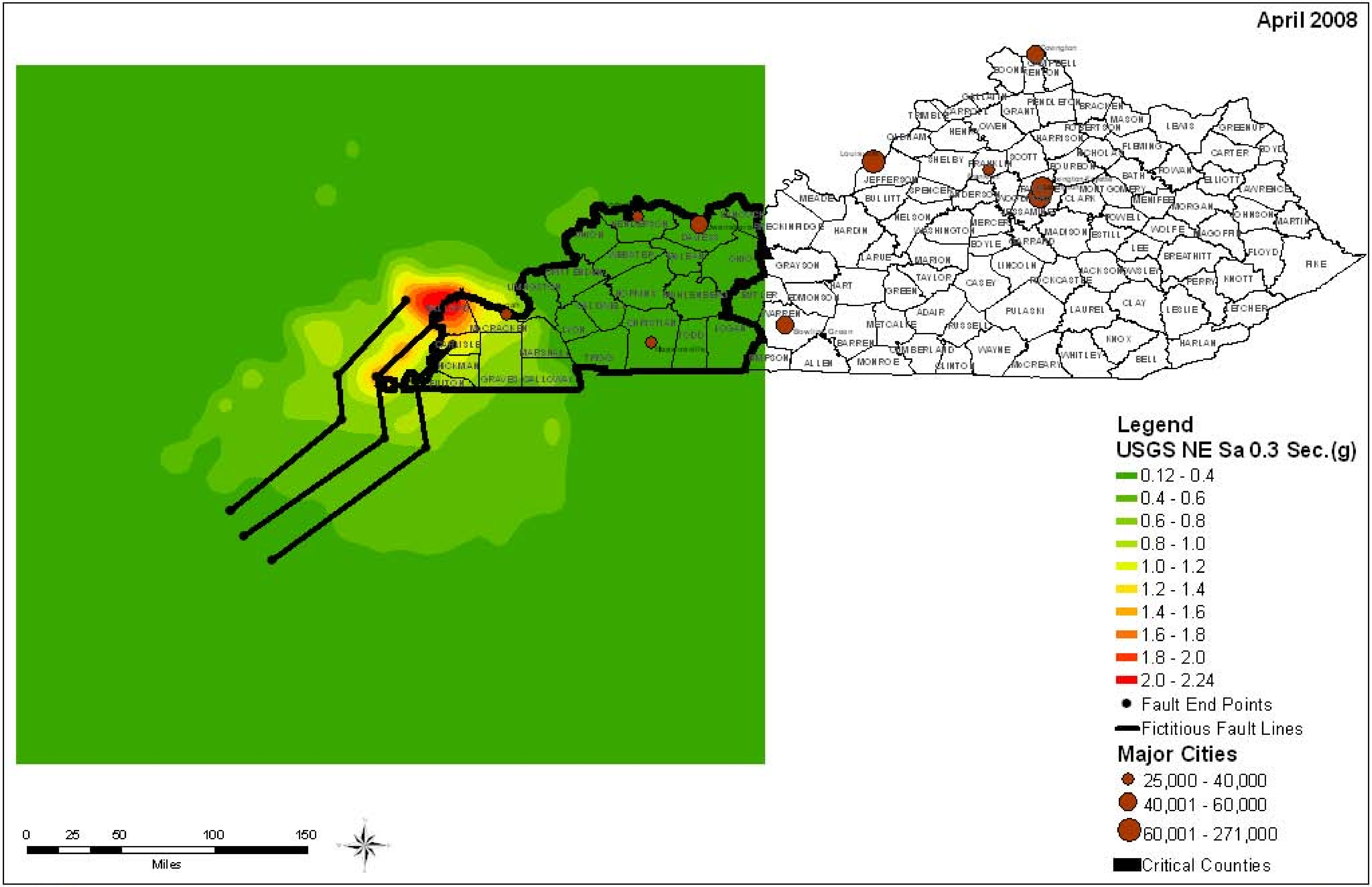

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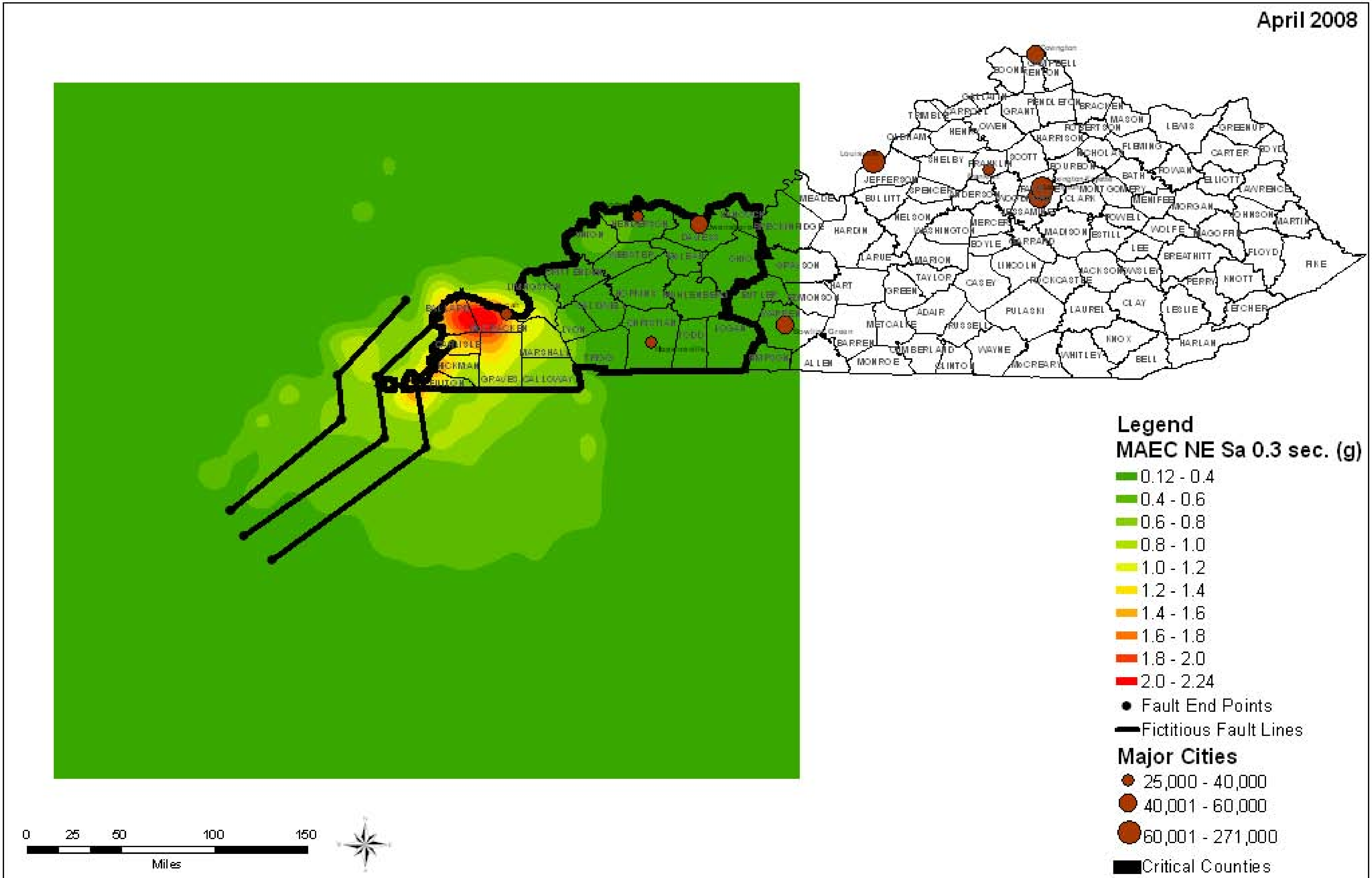

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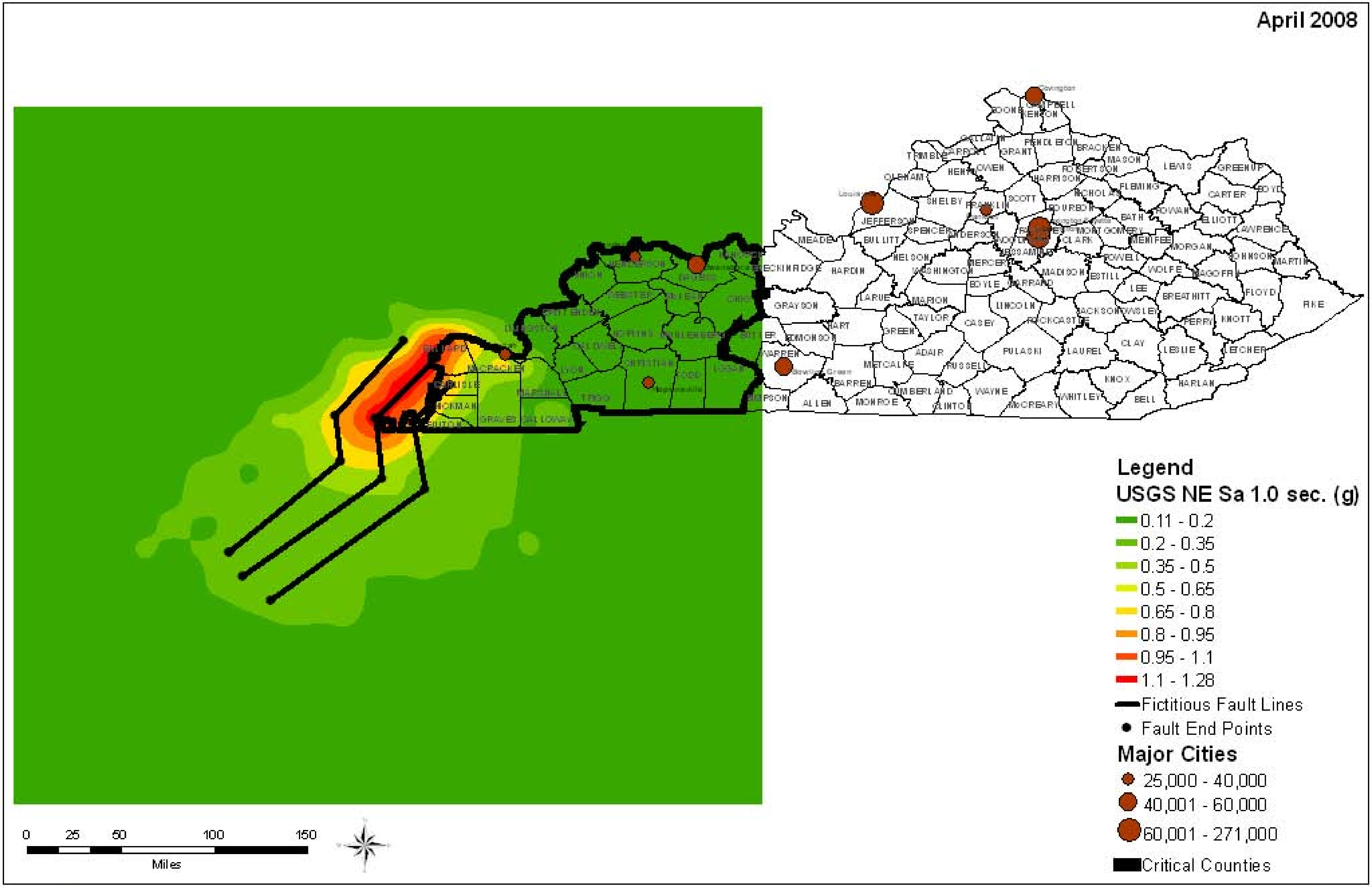

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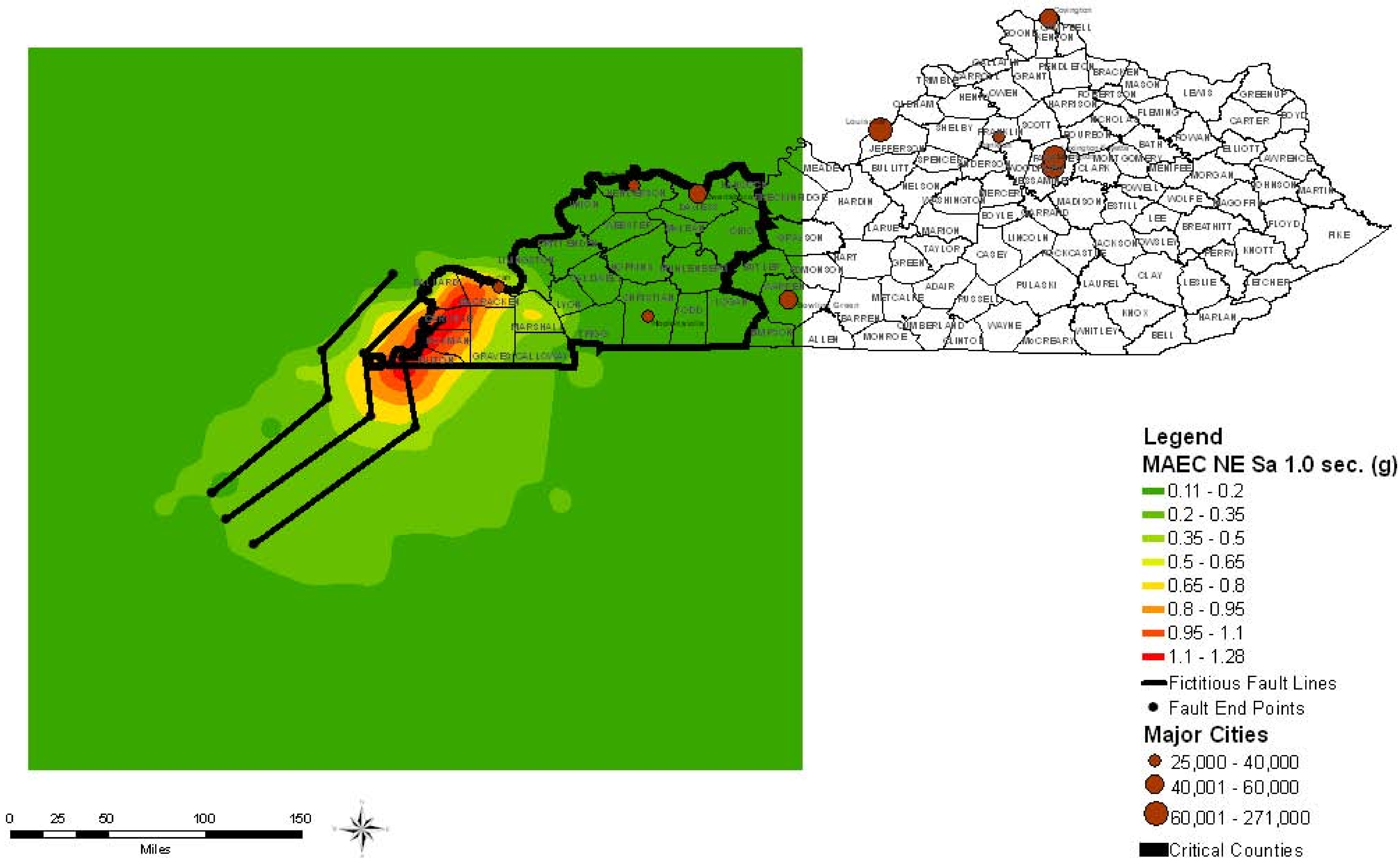

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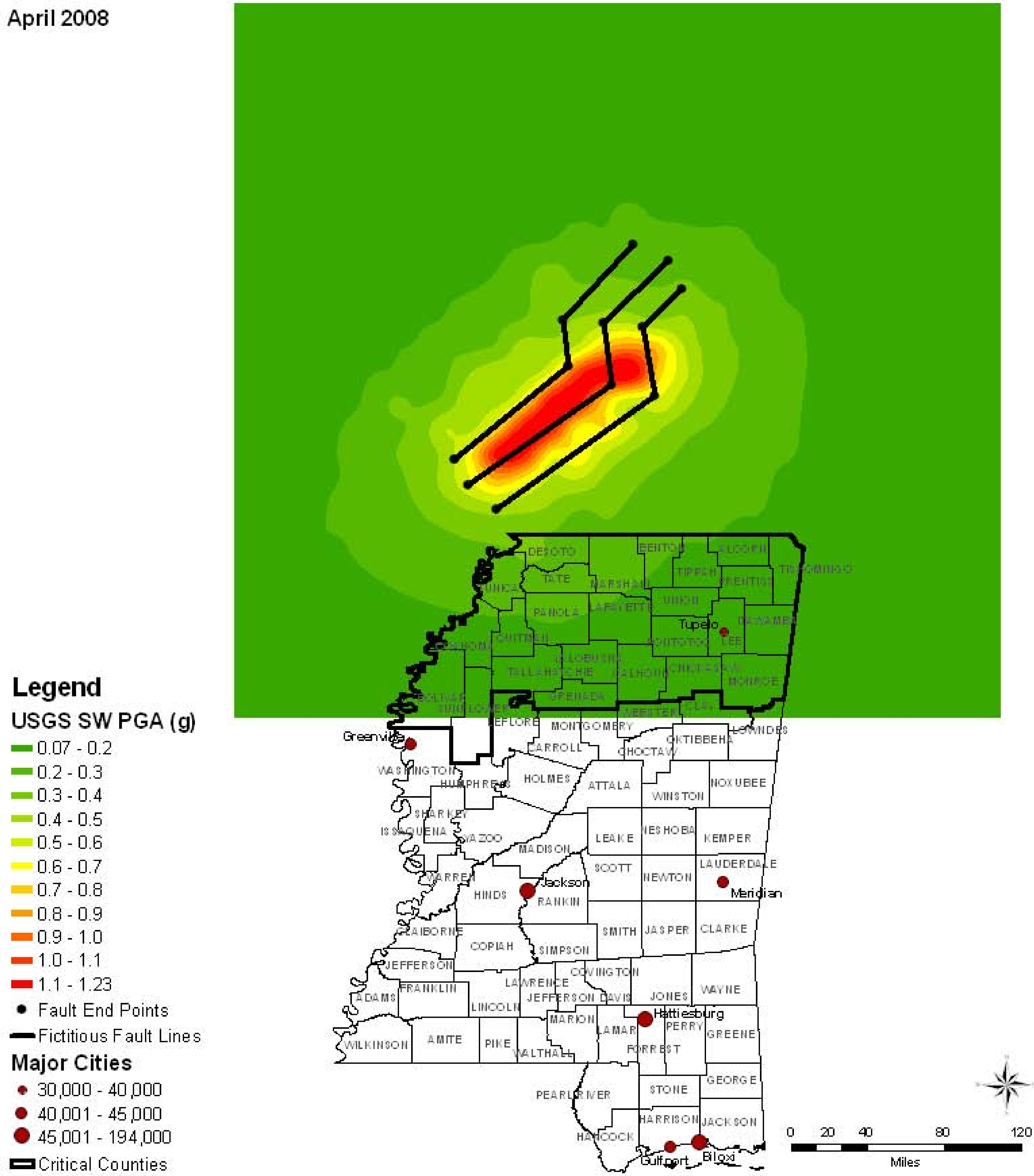
Mississippi PGA from USGS - New Madrid Seismic Zone: M7.7 Event

April 2008



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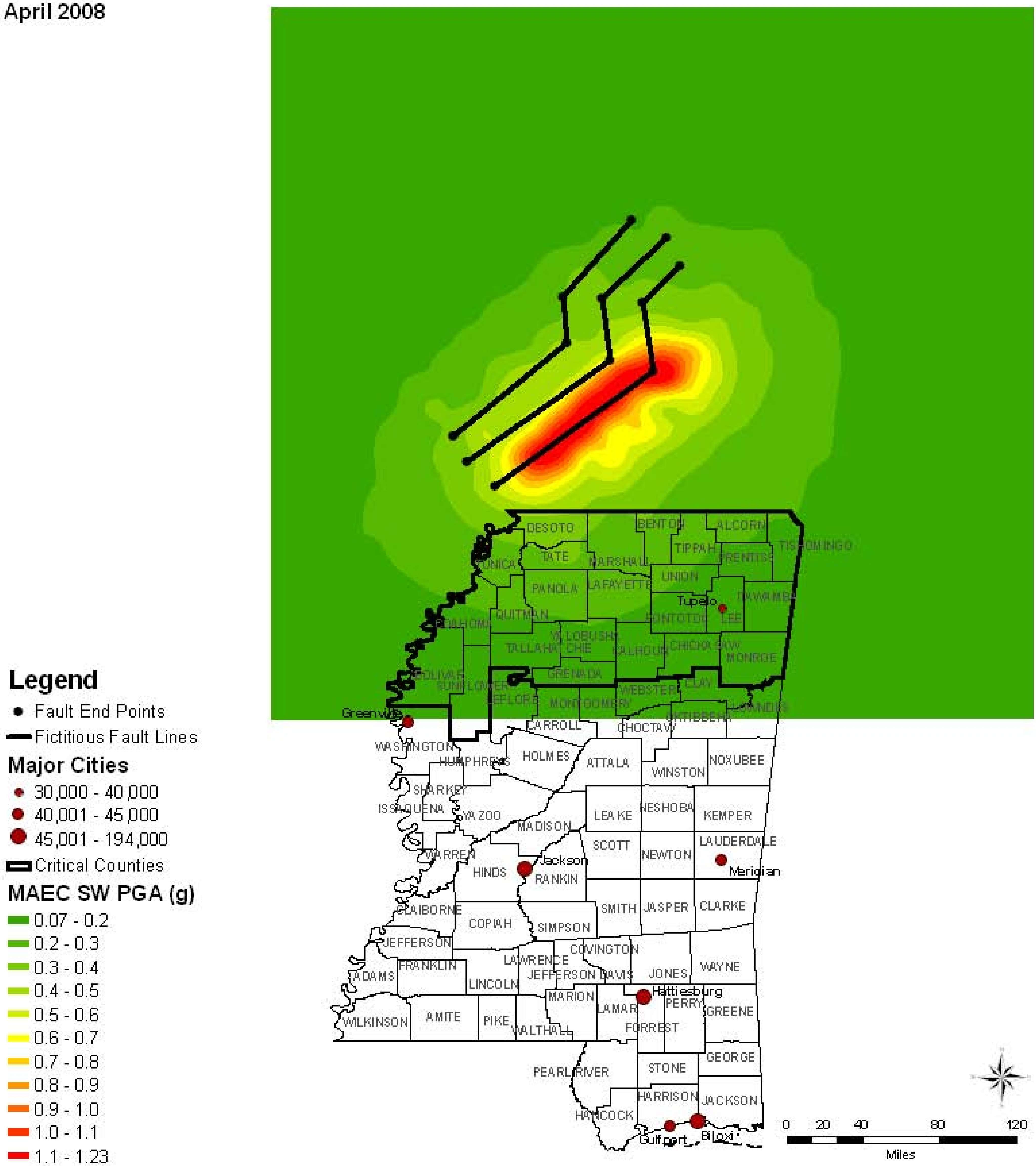

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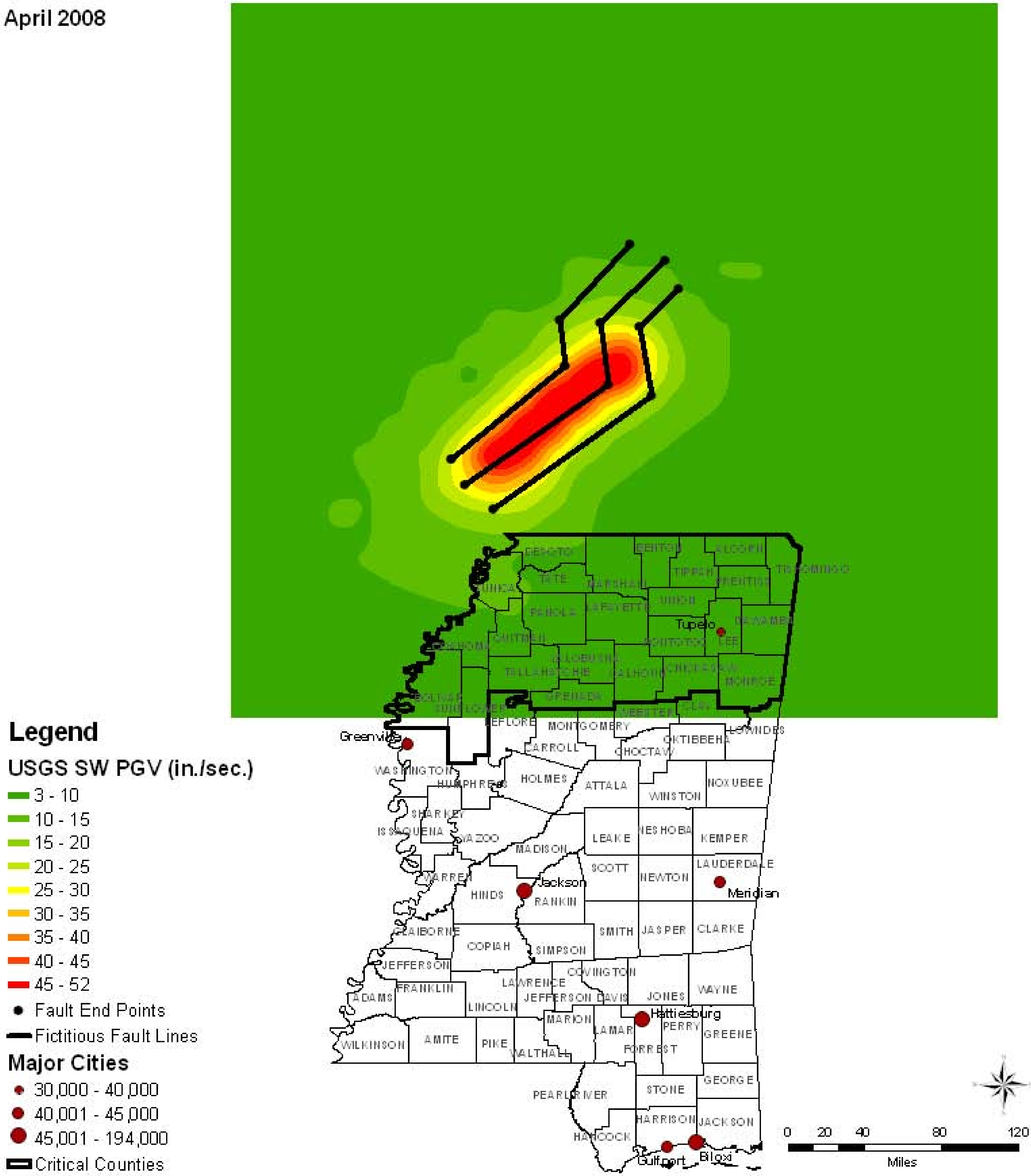

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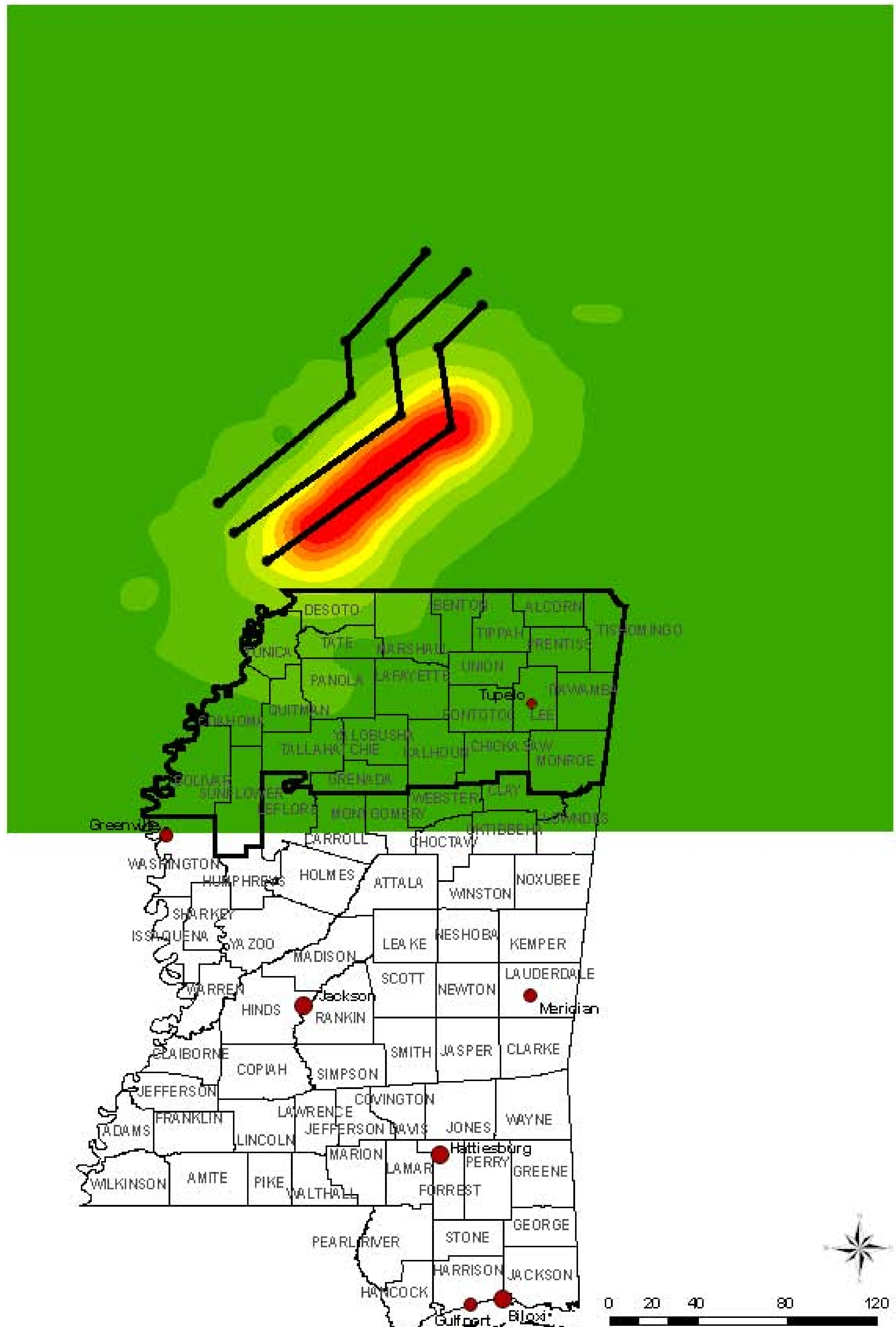

Legend

MAEC SW PGV (in./sec.)

- 3 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 52
- Fault End Points
- Fictitious Fault Lines

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000
- Critical Counties

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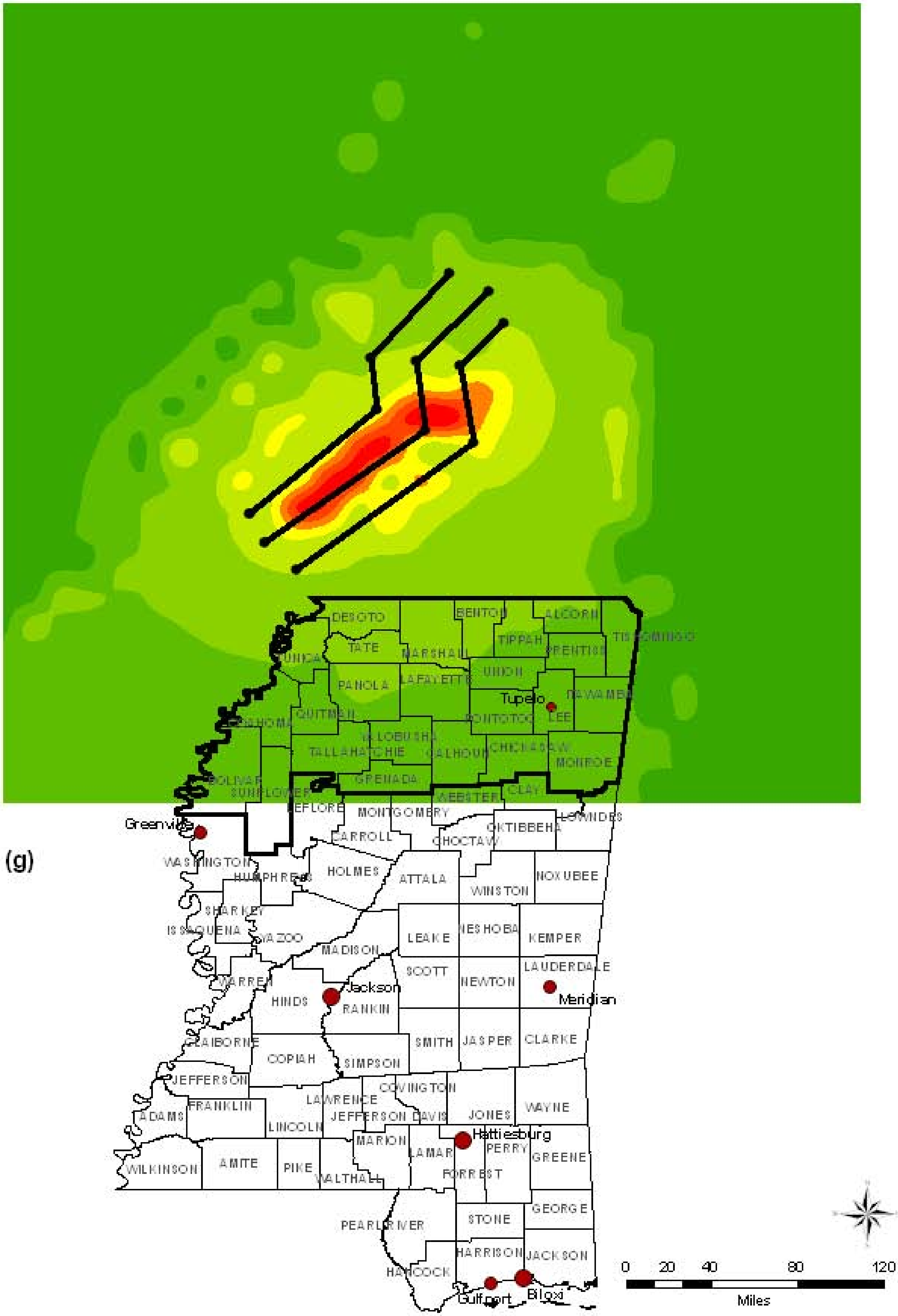

Legend

USGS SW Sa 0.3 sec. (g)

- 0.12 - 0.3
- 0.3 - 0.45
- 0.45 - 0.6
- 0.6 - 0.75
- 0.75 - 0.9
- 0.9 - 1.05
- 1.05 - 1.2
- 1.2 - 1.35
- 1.35 - 1.51
- Fault End Points
- Fictitious Fault Lines

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000
- Critical Counties

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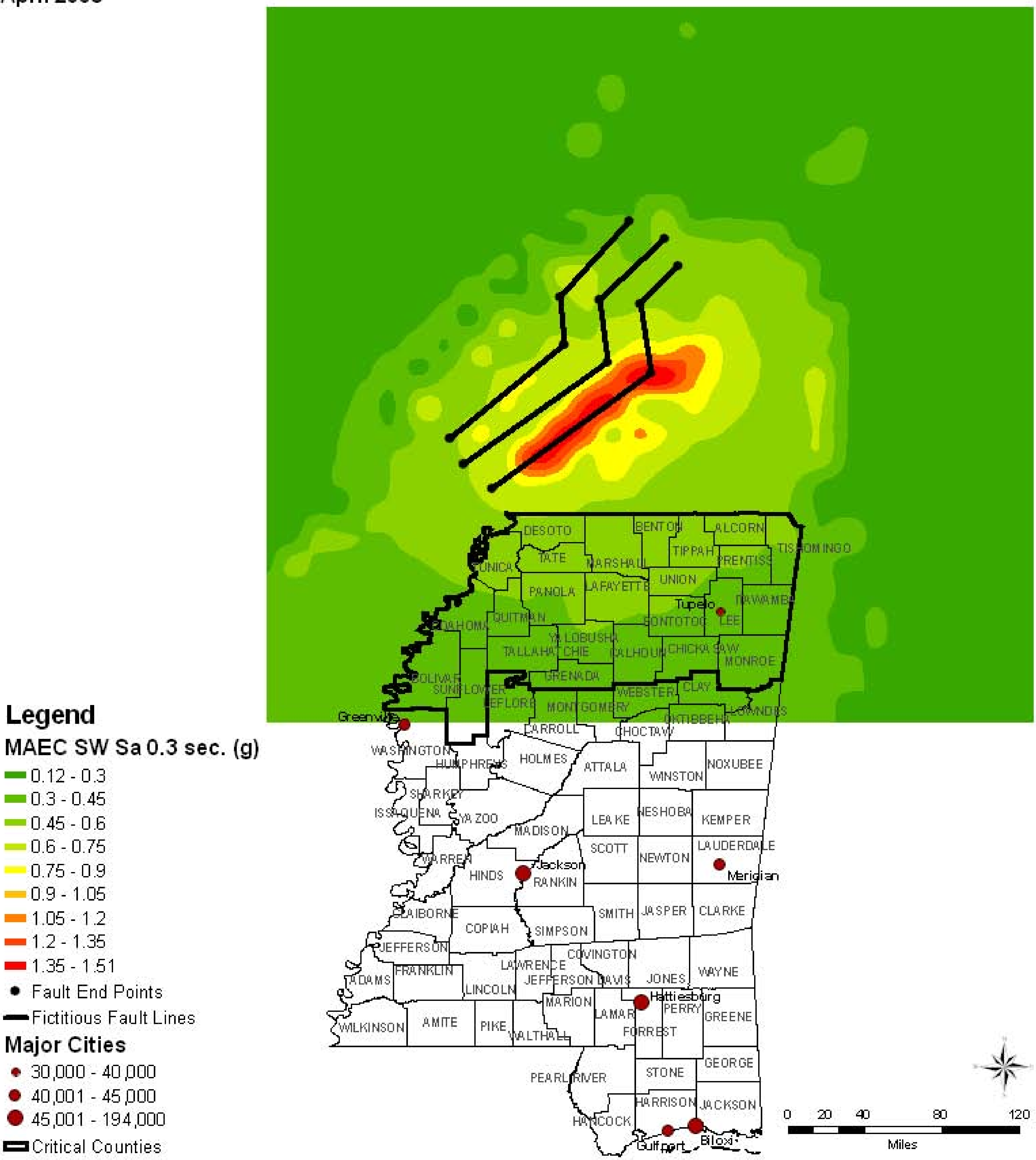

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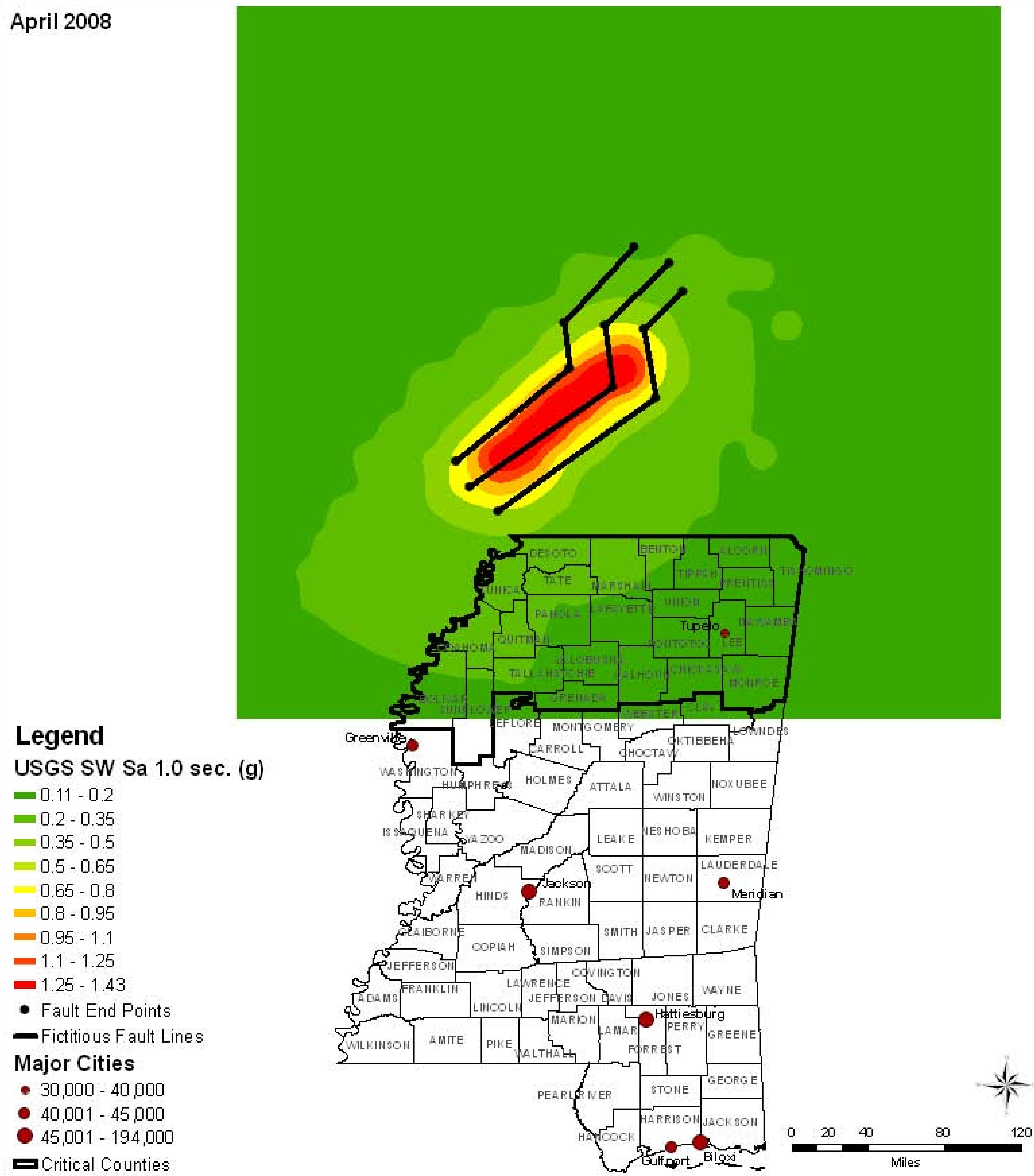

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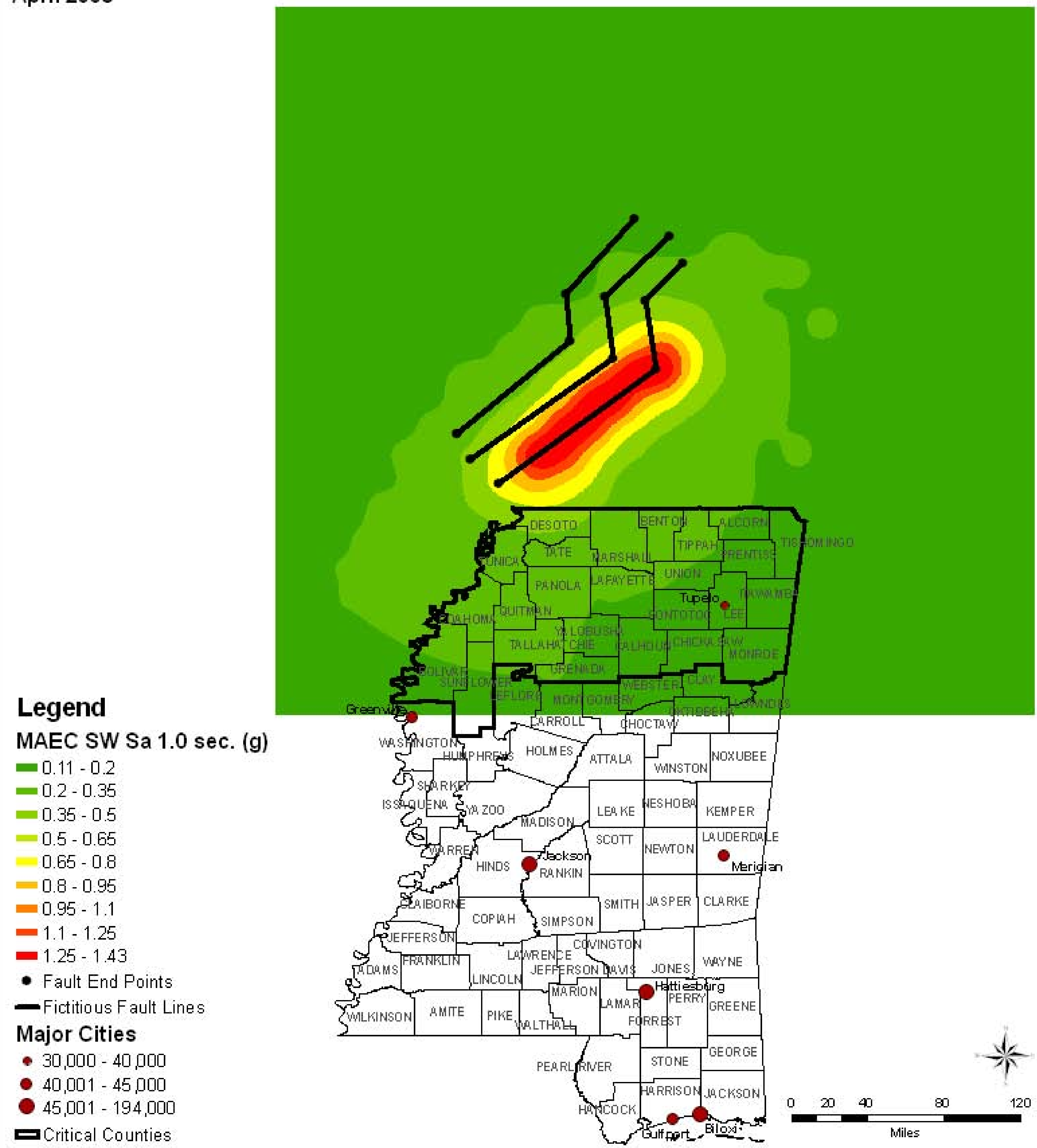

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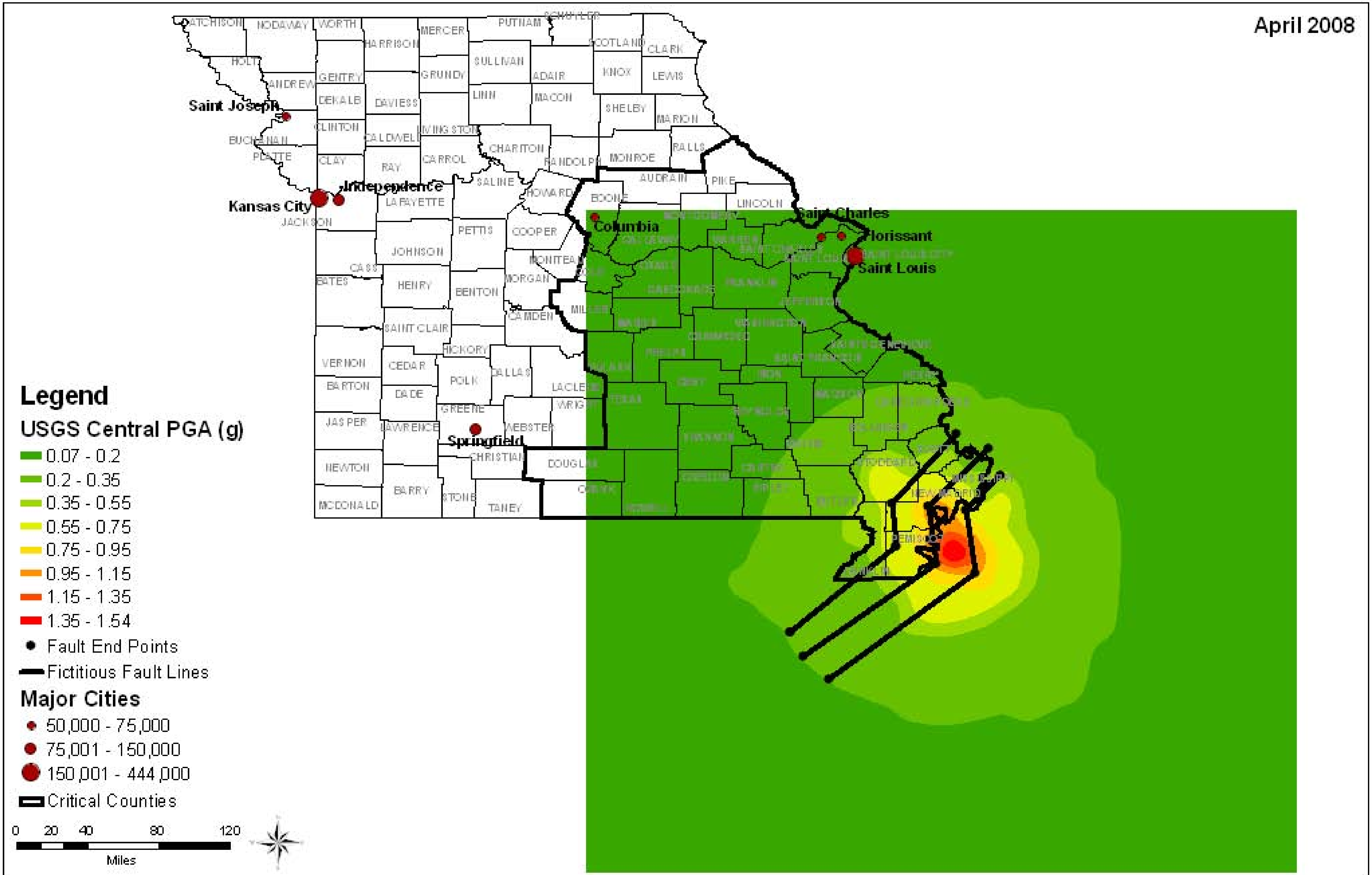
Missouri PGA from USGS - New Madrid Seismic Zone: M7.7 Event



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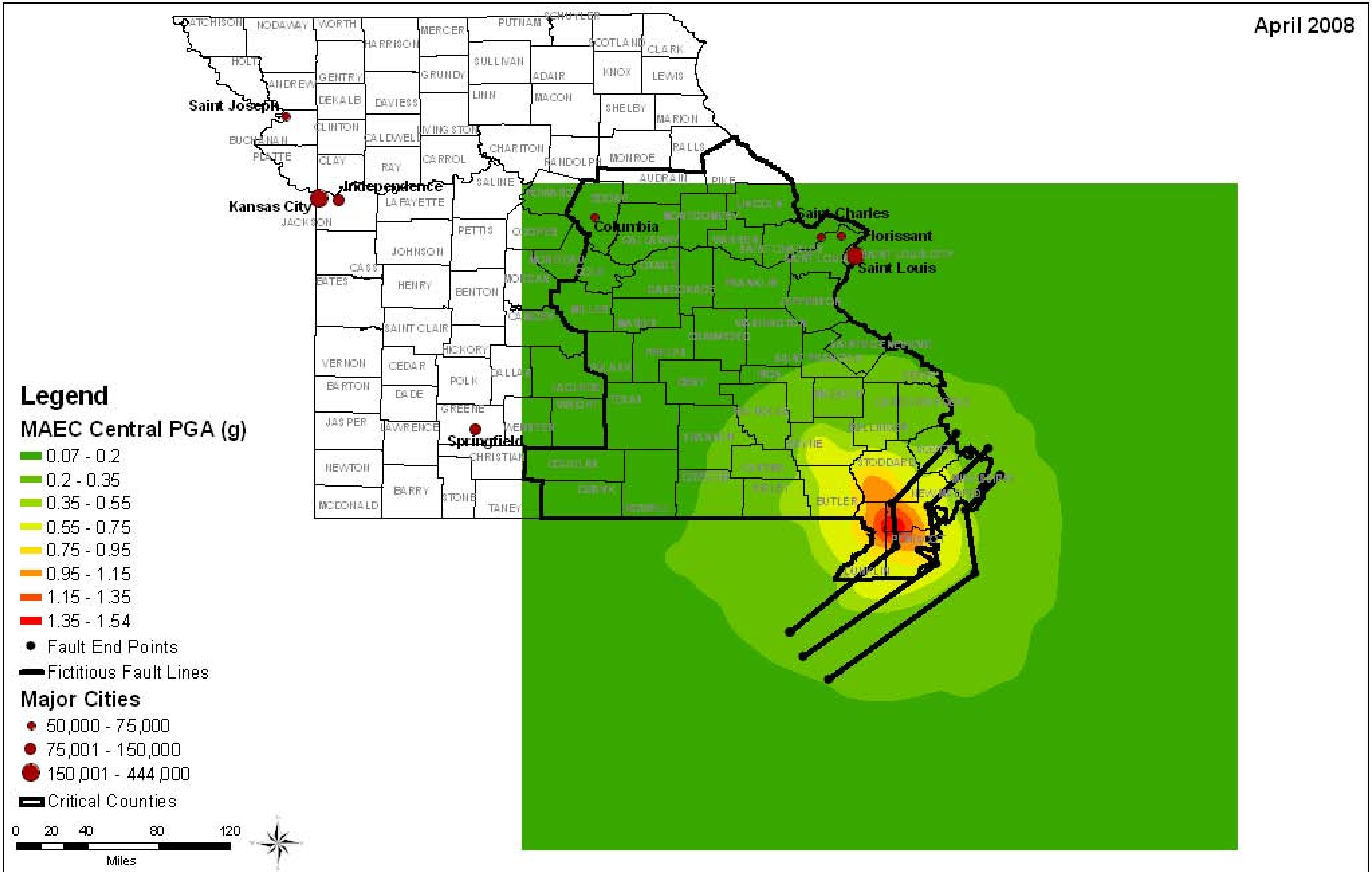

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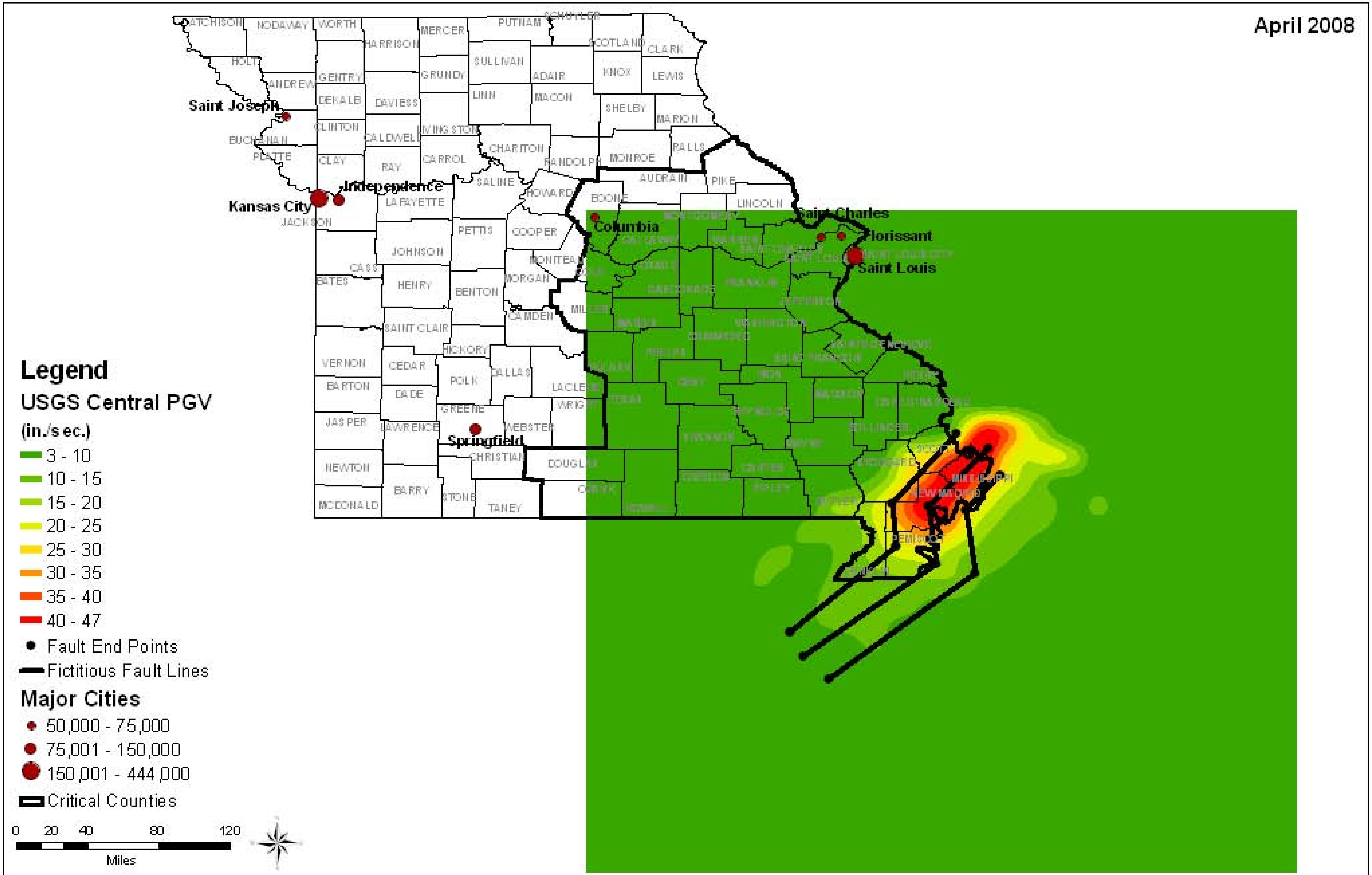
Missouri PGV from USGS - New Madrid Seismic Zone: M7.7 Event



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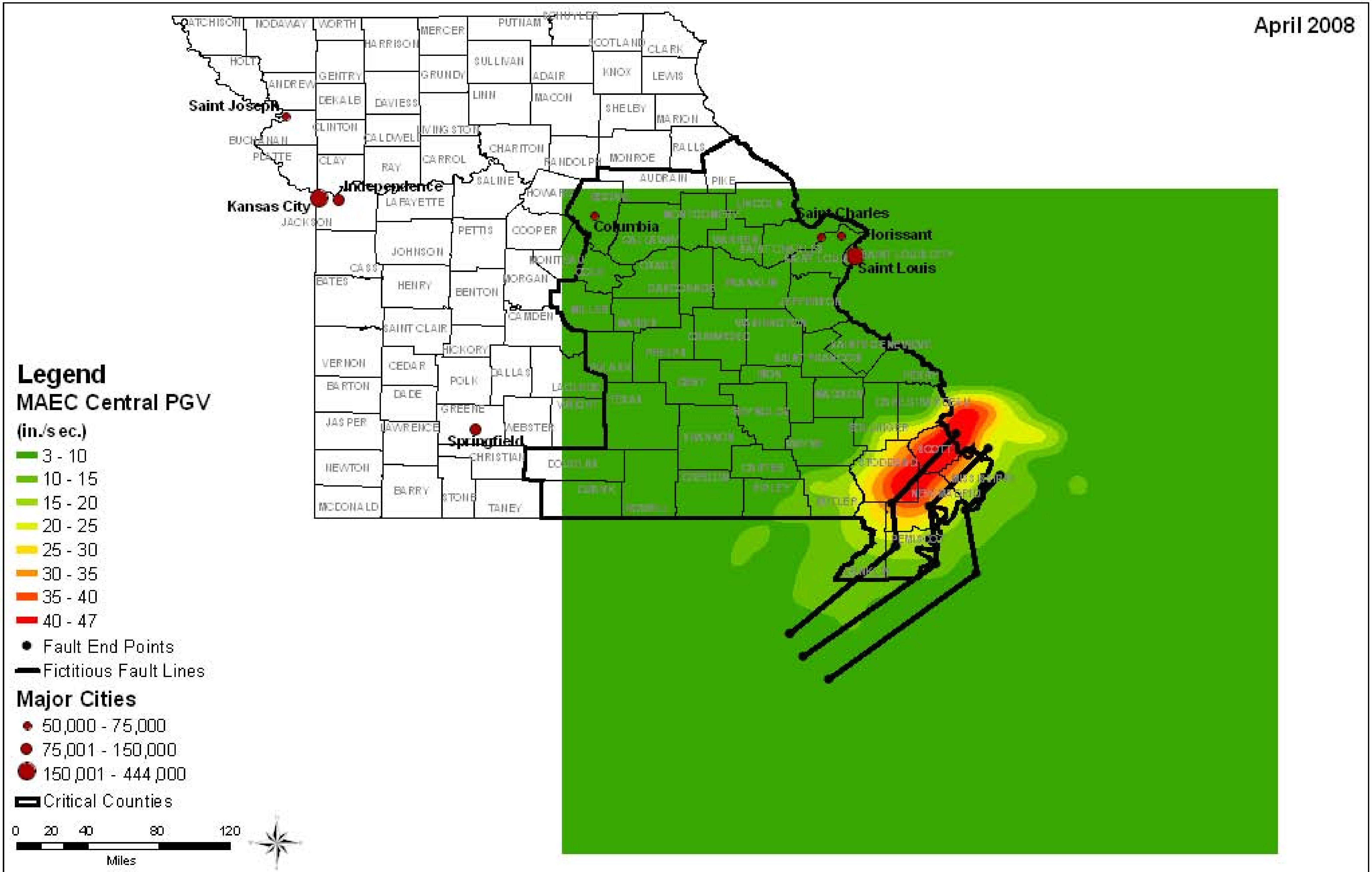

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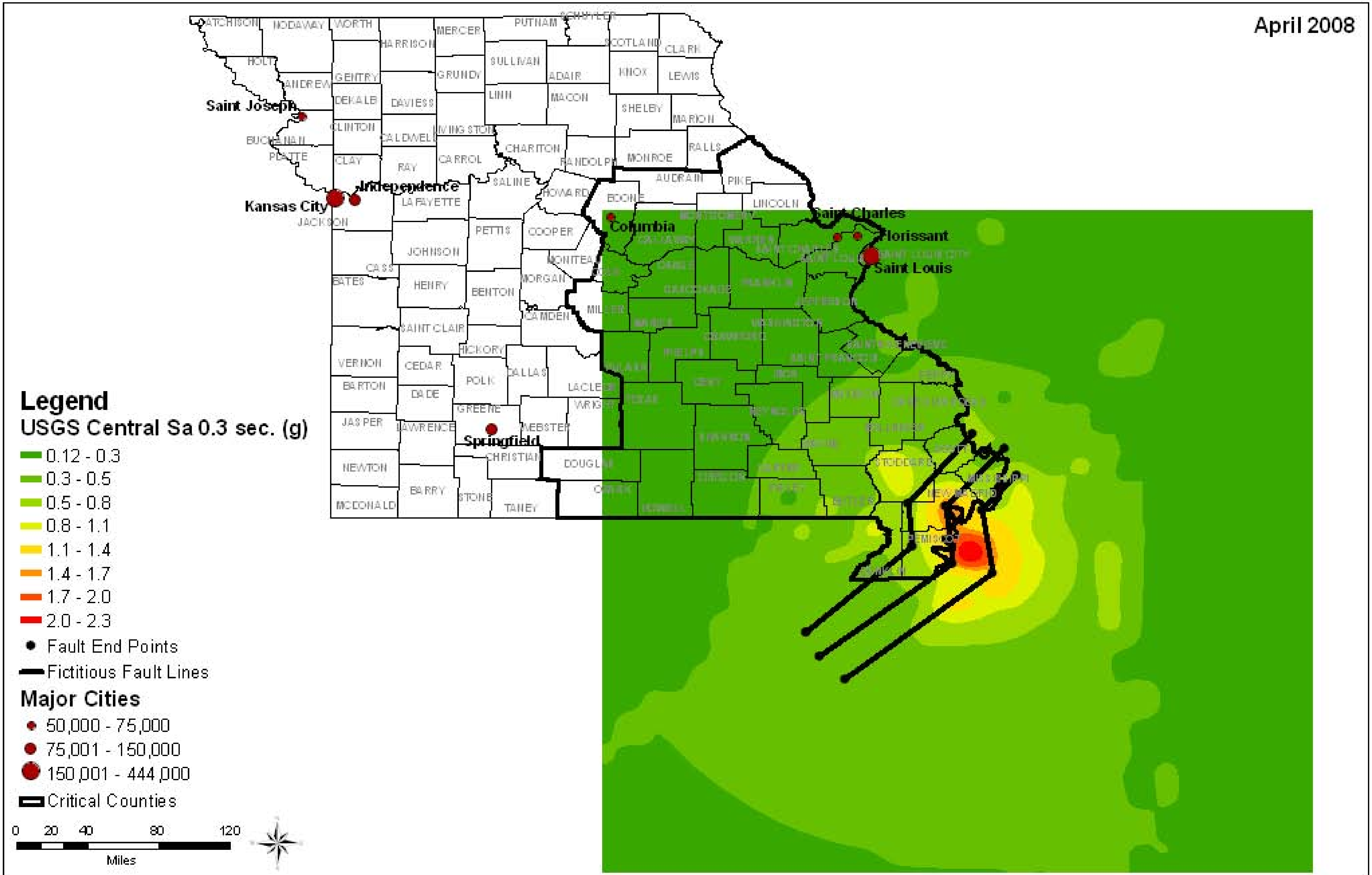
Missouri Sa 0.3 sec. from USGS - New Madrid Seismic Zone: M7.7 Event



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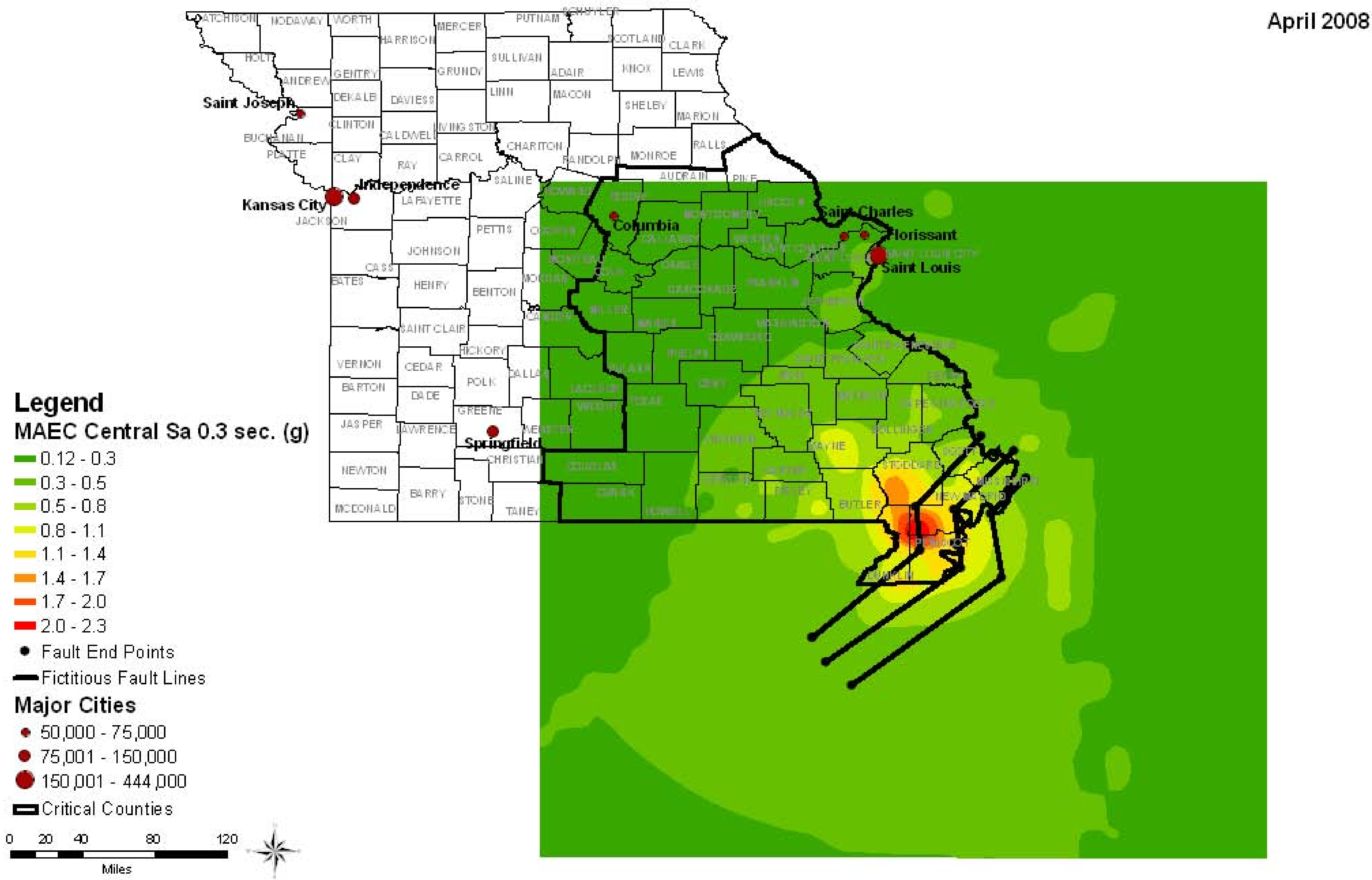
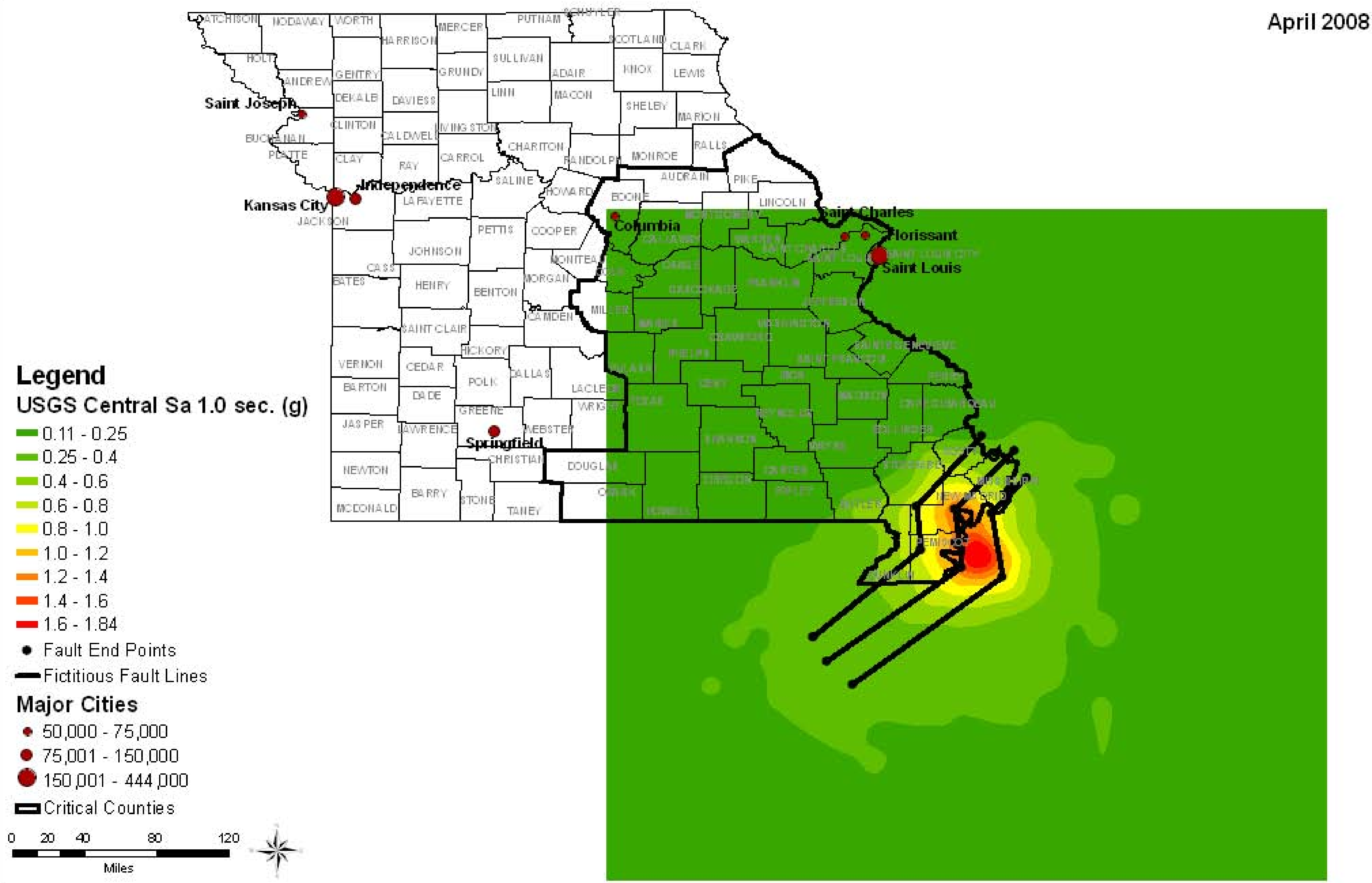


Missouri Sa 1.0 sec. from USGS - New Madrid Seismic Zone: M7.7 Event



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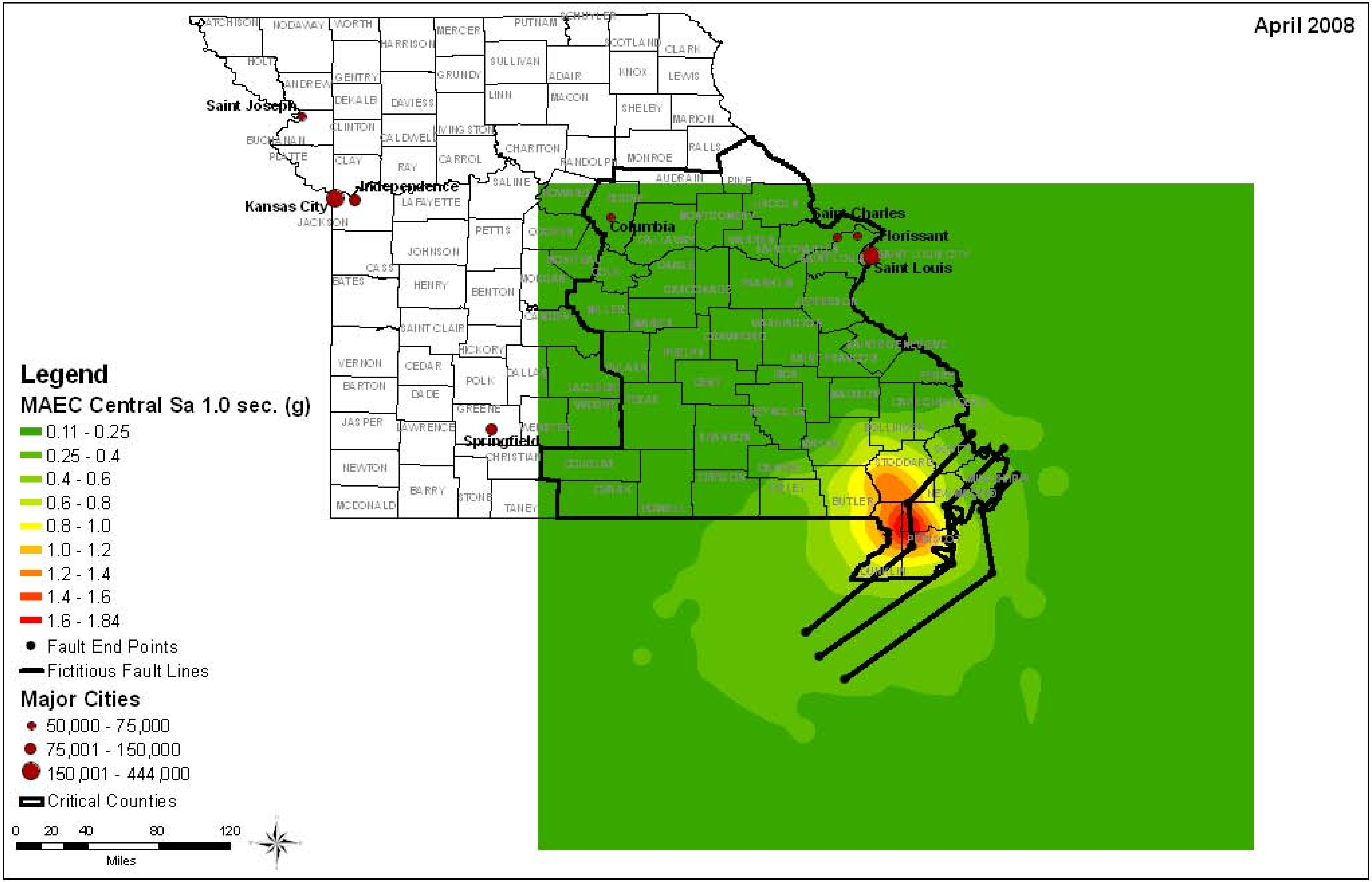

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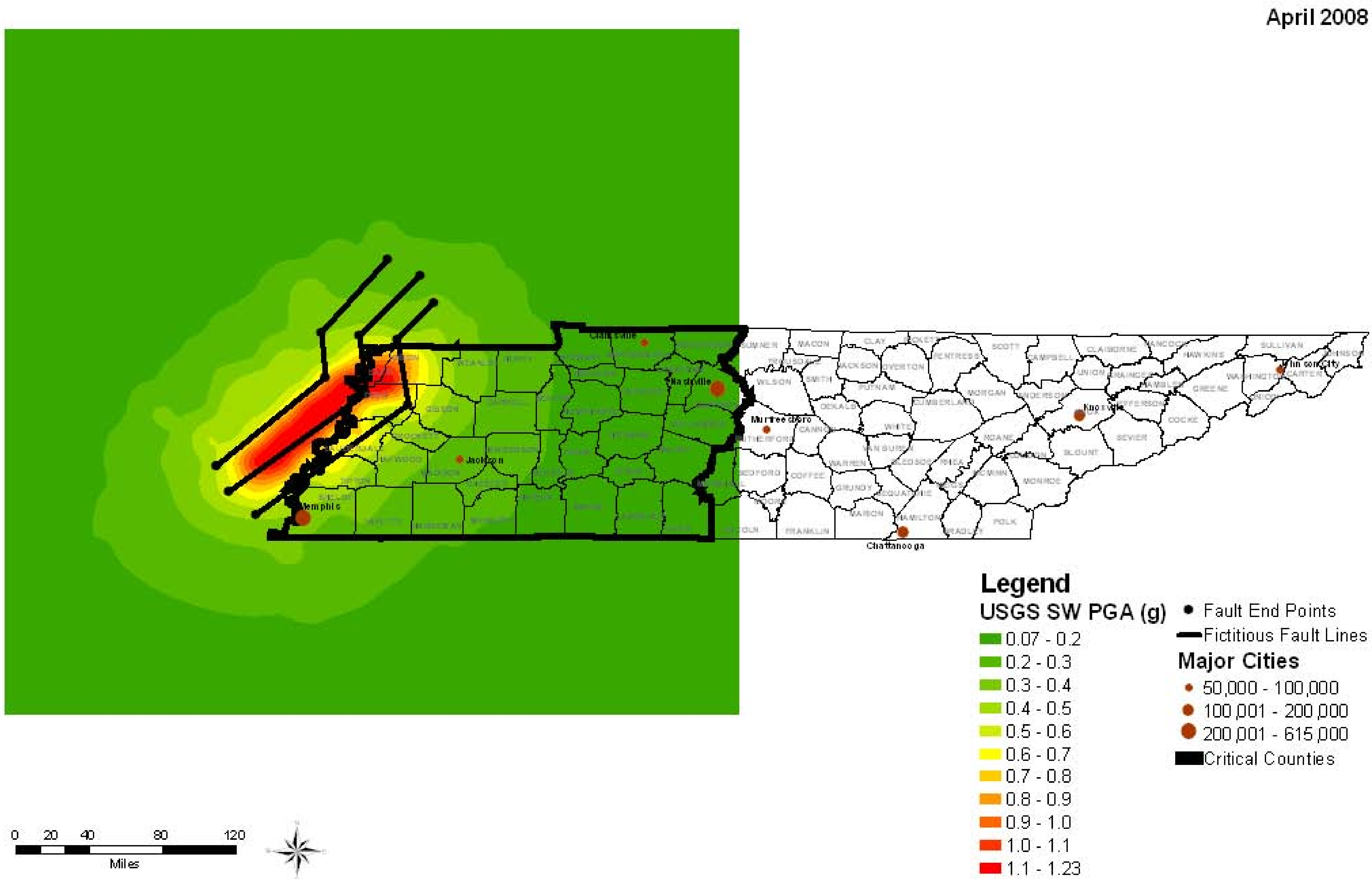

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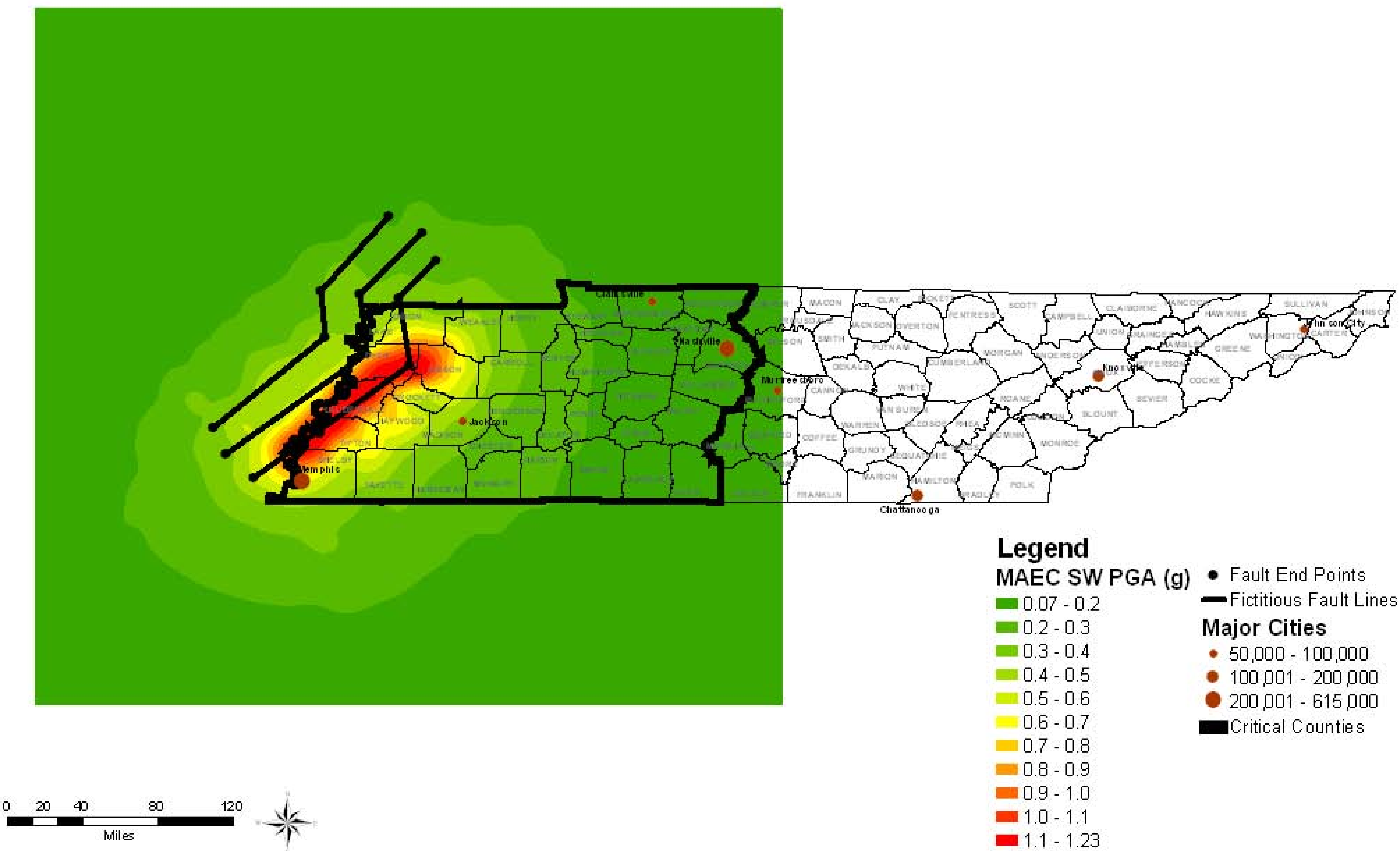

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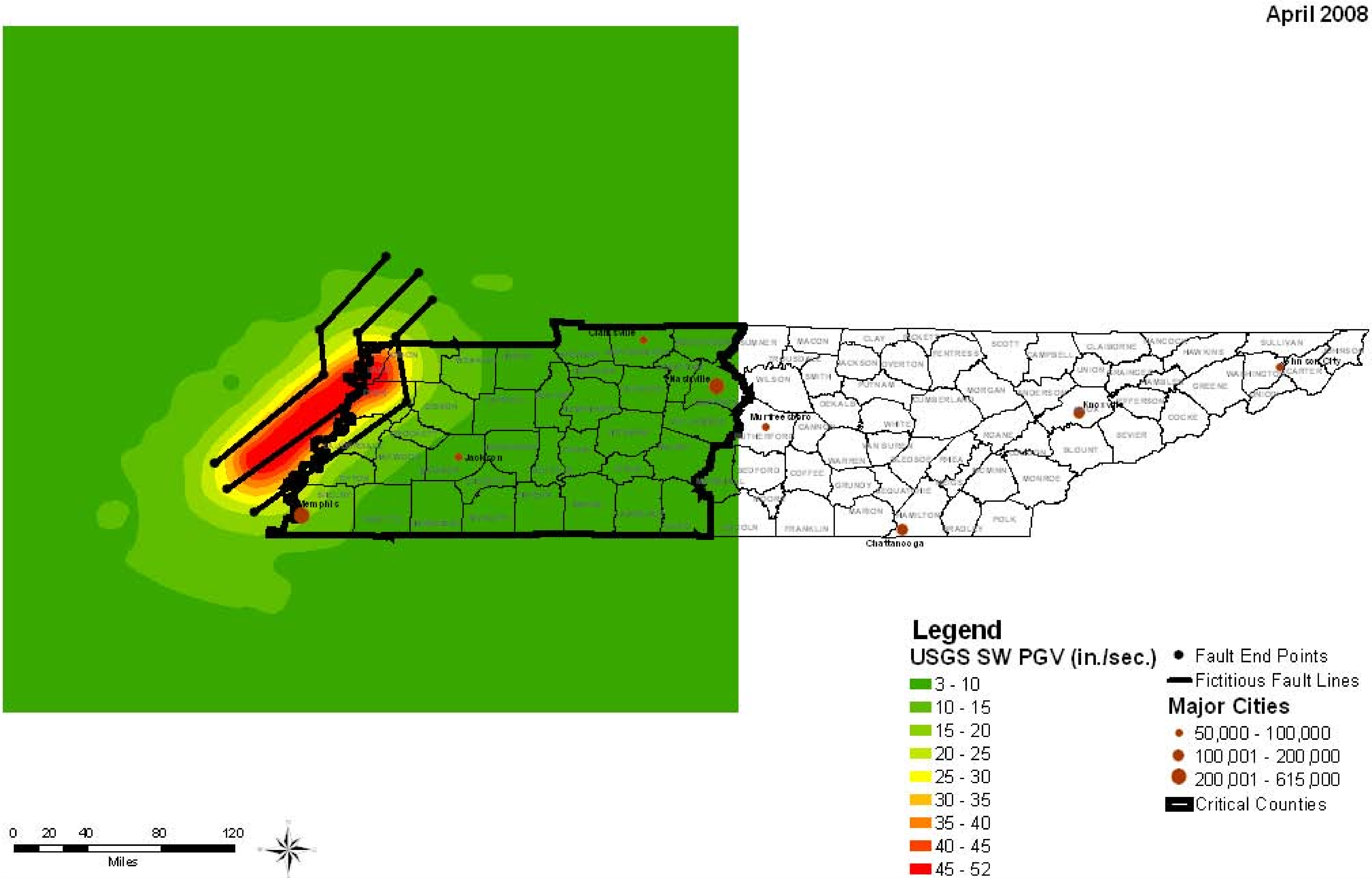

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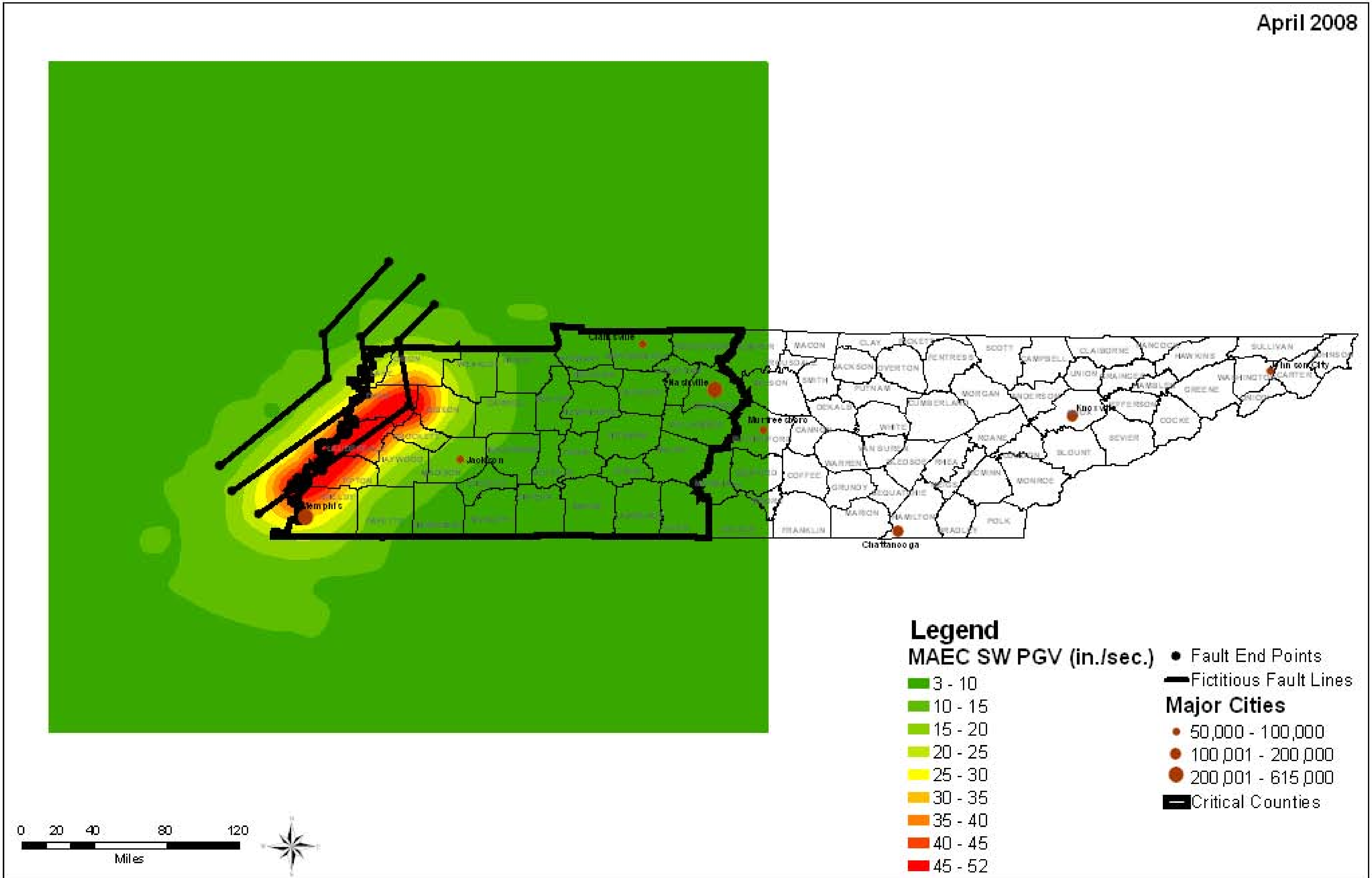

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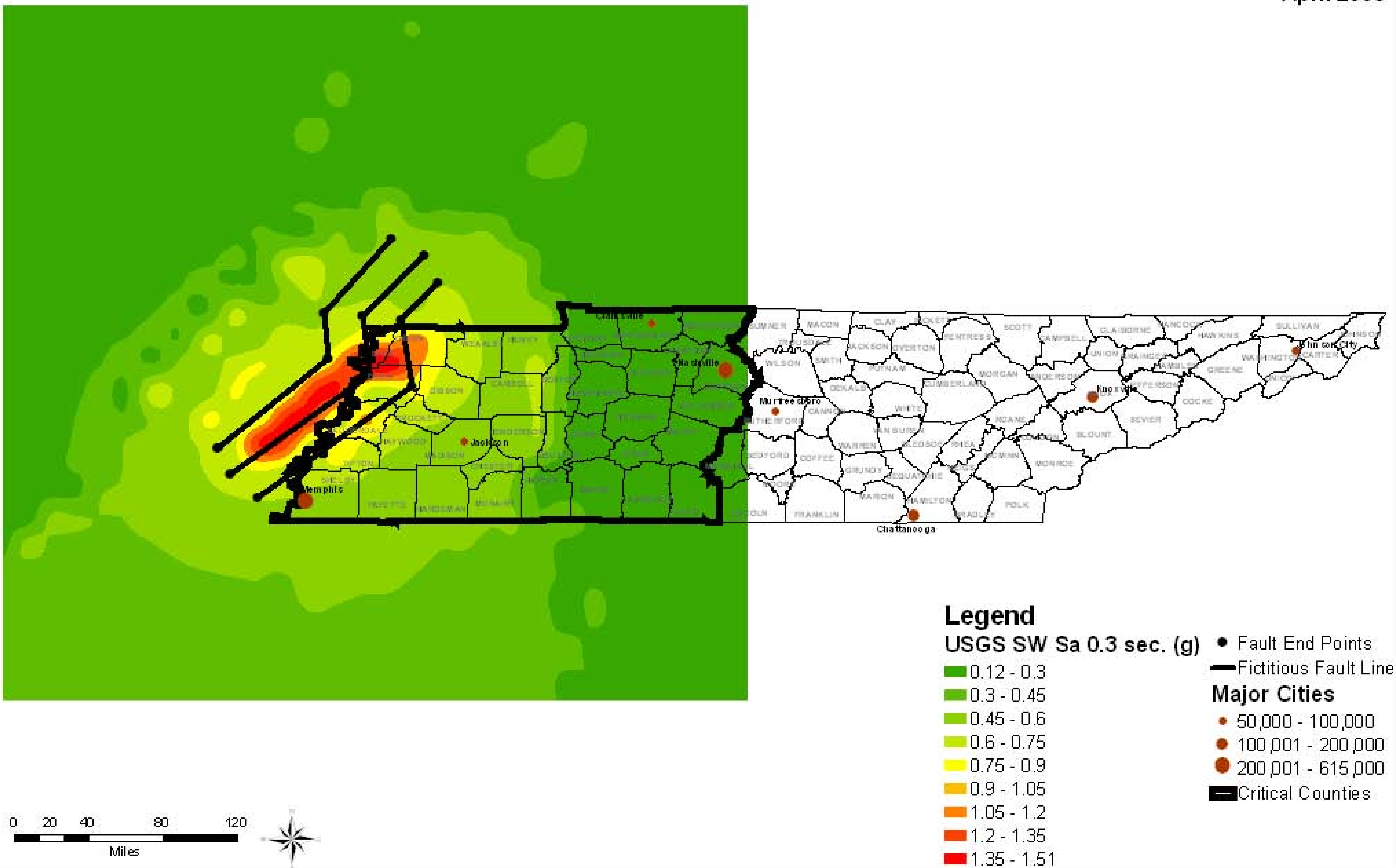
April 2008



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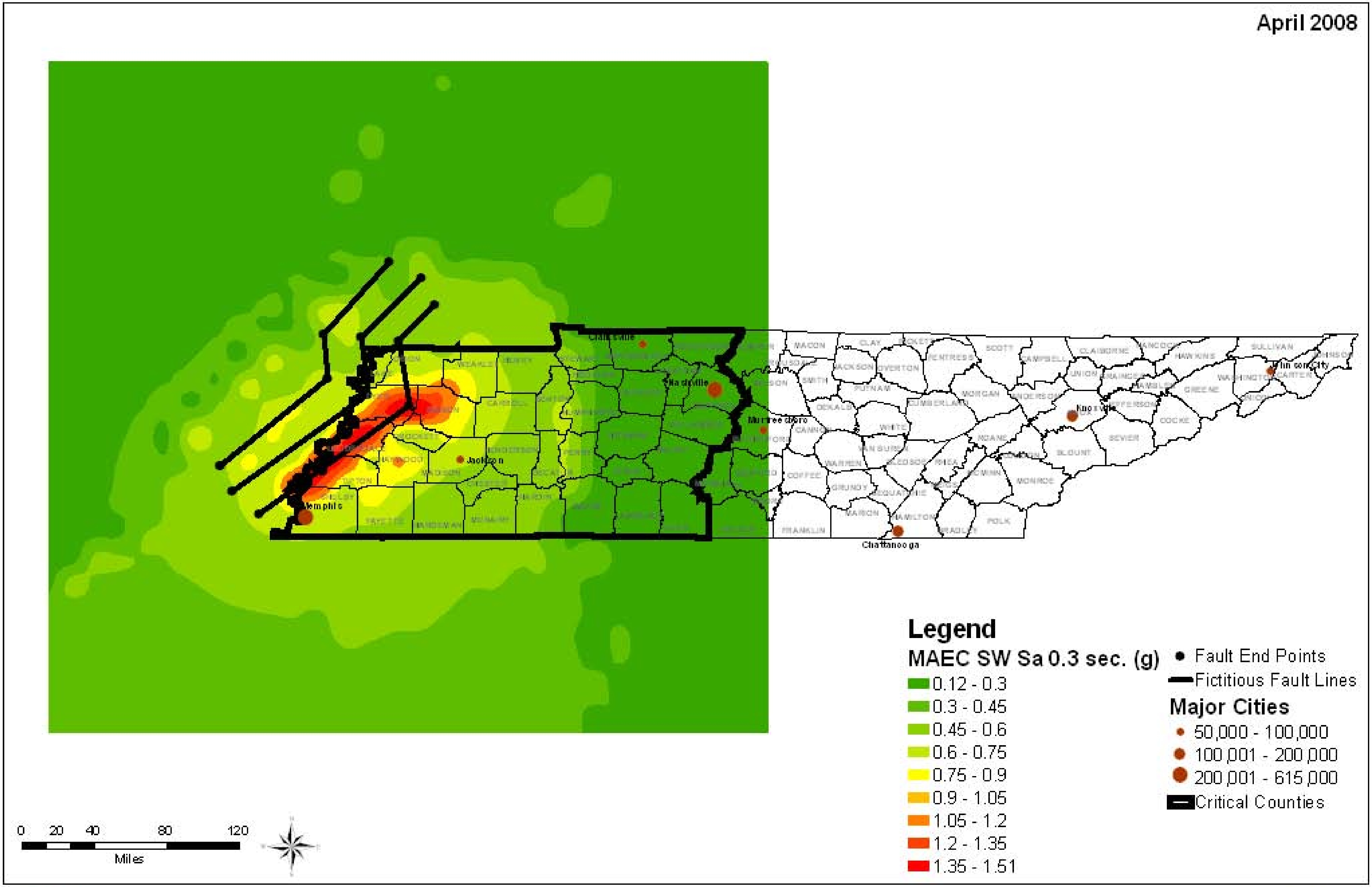
Tennessee Sa 0.3 sec. from MAEC - New Madrid Seismic Zone: M7.7 Event



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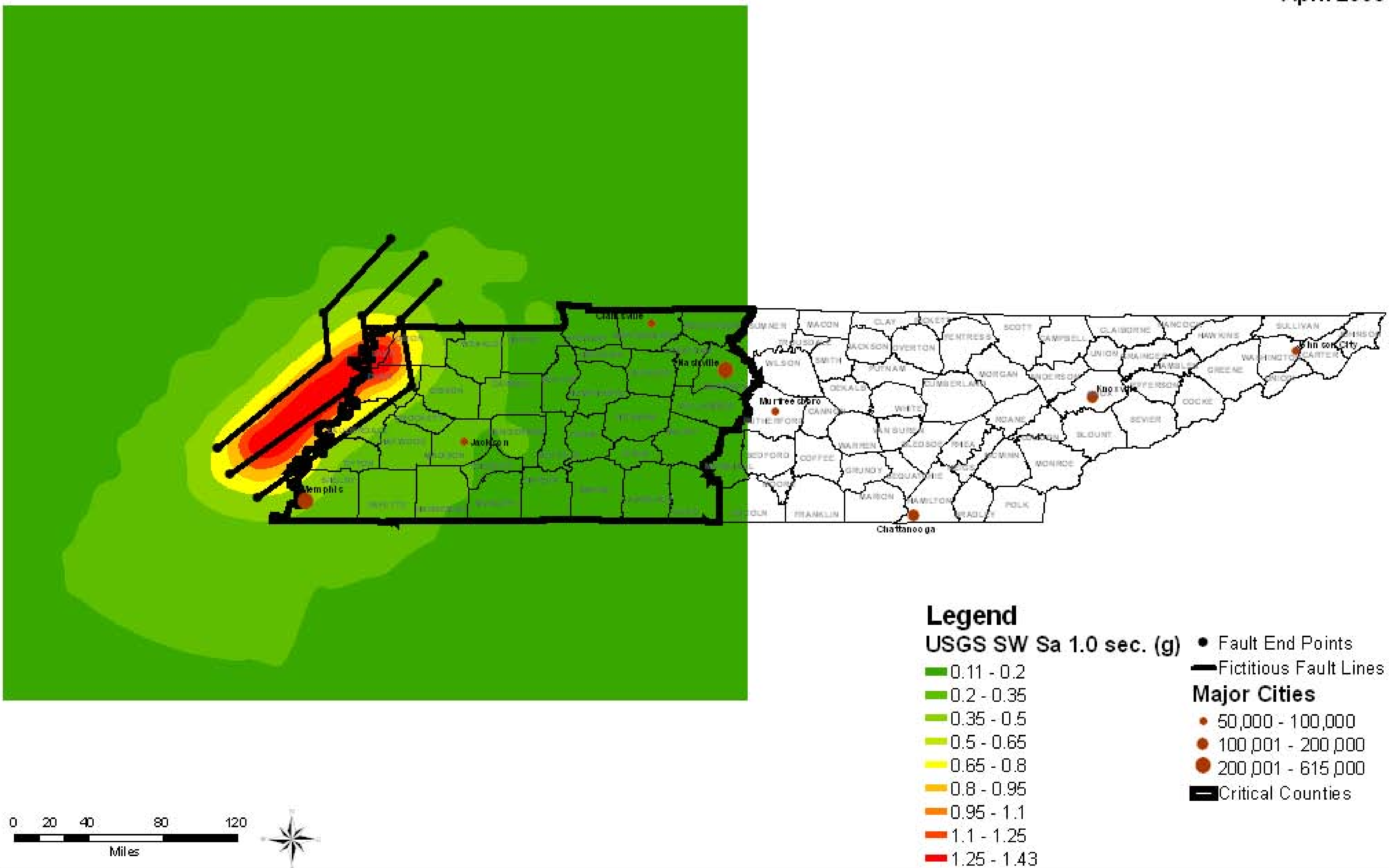

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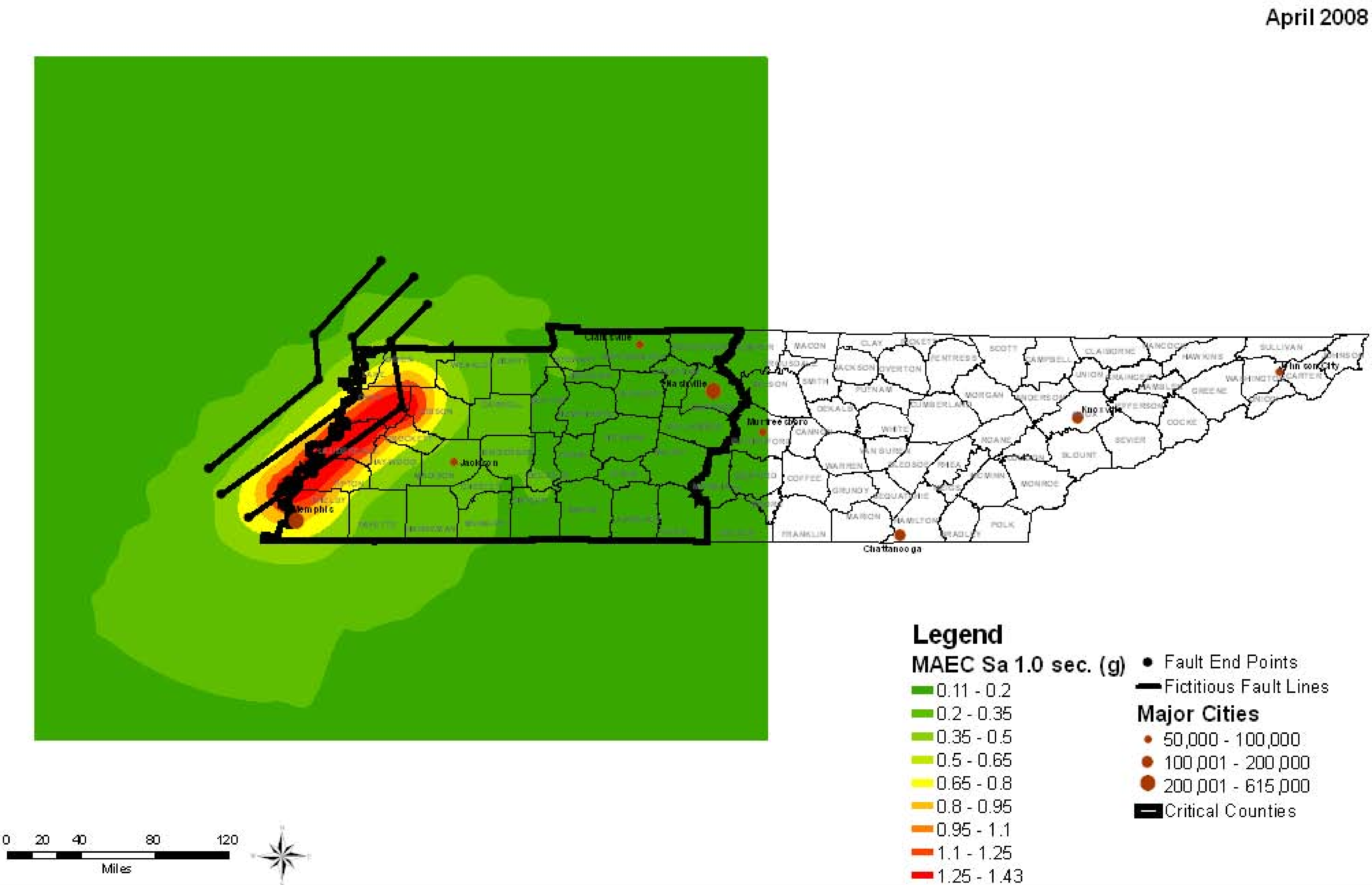

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Appendix II: Inventory

This appendix details the inventory employed in all State Reports. Inventory data used in state workshop scenarios is a combination of HAZUS-MH MR2 default data and 2007 Homeland Security Infrastructure Program (HSIP) datasets with additional inventory collected by the MAE Center for specific regions. The inventory required for a HAZUS-MH MR2 analysis is divided into numerous categories, some of which have been updated for the impact assessment provided for state workshops. The 'general building stock' defines all buildings in a state that are not related to transportation and utilities services. This dataset includes residential, commercial, industrial, government, education, religious, and agricultural buildings. These buildings are aggregated at the census tract level, meaning all buildings are summed by construction type and occupancy type independently for a given census tract. The general building stock was not updated for state workshop analyses due to a lack of refined data for the areas requiring assessment, so HAZUS-MH MR2 default inventory was used here.

'Essential facilities' is a dataset that is broken out from the general building stock. These facilities include schools, hospitals, fire stations, police stations, and emergency operation centers and are separated from the general building stock due to their critical importance in rescue efforts following a natural disaster. Essential facilities information was updated with HSIP data for each facility type. Additional hospitals from HSIP data were added and classified by size (based on number of beds). Primary and secondary schools, as well as colleges and universities, were added to HAZUS-MH MR2 inventory and classified accordingly. Fire and police station datasets were supplemented with HSIP data as well. All new essential facilities taken from HSIP datasets were assigned the HAZUS-MH MR2 default structure type associated with that particular facility type. For example, HAZUS-MH MR2 classifies all fire stations as unreinforced masonry, low-rise (URML) construction. Since structure type is not defined within the HSIP datasets, all fire stations added from that data were assigned the HAZUS-MH MR2 default structure type URML. The same is true for all other essential facility types as follows:

- Schools, police stations, EOCs structure type: URML
- Hospital structure type: PC1

Additionally, replacement cost data was updated to reflect more current cost data. Eduardo Escalona, at the time working with FEMA VII, assisted the MAE Center with updates to essential facilities. For more detailed information on the updates to essential facilities, reference is made to Escalona.[1]

The State of Illinois impact assessment also drew inventory data from a previous MAE Center project, SE-1, with Professors Steven French of the Georgia Institute of Technology and Robert Olshansky of the University of Illinois at Urbana-Champaign. This report includes essential

[1] Eduardo Escalona. (Formerly of FEMA Region VII) currently PBS&J.

facilities data for 23 counties in southern Illinois. For further information on the essential facilities data included in the State of Illinois impact assessment, please contact the MAE Center[2].

Transportation, utility, and high potential-loss facility (HPLF) datasets were also updated with HSIP data. The only exception to this is the potable water facility dataset. The HSIP critical infrastructure data does not include information on potable water facilities, and thus no updates to HAZUS-MH MR2 inventory were completed. Transportation, utility and HPLF inventory datasets were appended to include HSIP data. HAZUS-MH MR2 inventory was compared with HSIP data for each facility type and when the HSIP dataset reported more facilities than HAZUS-MH MR2 default inventory, those additional facilities from the HSIP dataset were added to the HAZUS-MH MR2 default inventory. This means that no facilities were deleted from HAZUS-MH MR2 default inventory, but rather facilities were added to create the most comprehensive dataset available. Kirk Chesla of Innovative Emergency Management (IEM) assisted the MAE Center with inventory updates for transportation, utility, and HPLF facilities. More specifically datasets updated with HSIP data include:

- Transportation Systems
  - Highway Bridges
  - Railway Bridges
  - Ferry Facilities
  - Bus Stations
  - Airports
  - Light Rail Facilities and Bridges
- Utility Systems
  - Waste Water Facilities
  - Natural Gas Facilities
  - Major Natural Gas Transmission Pipelines
  - Oil Facilities
  - Major Oil Transmission Pipelines
  - Electric Power Facilities
  - Major Electric Transmission Lines
  - Communication Facilities
- High Potential-Loss Facilities
  - Dams
  - Nuclear Power Facilities
  - Military Installations
  - Hazardous Materials Facilities

In addition, regional transmission lines for natural gas and oil were added from the HSIP 2007 data. Replacement costs were also added to these major natural gas and oil transmission lines. Pipeline inventory updates were also assisted by Eduardo Escalona (contact information above).

The following tables illustrate differences between HAZUS-MH MR2 default inventory and the inventory updates completed for the State Reports. Infrastructure categories are listed by state.

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[2] Mid-America Earthquake Center, SE-1 "Inventory of Essential Facilities in Mid-America." Contact Person: Timothy Gress, Phone: 217-244-6302, Email: tgress@uiuc.edu

Table 1: Alabama Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	122	137
Schools	1,857	1,870
Fire Stations	729	1,388
Police Stations	470	496
Emergency Operation Centers	27	27
Transportation Facilities		
Highway Bridges	11,857	14,597
Highway Tunnels	0	0
Railway Bridges	88	118
Railway Facilities	104	109
Railway Tunnel	0	9
Bus Facilities	16	24
Port Facilities	274	274
Ferry Facilities	0	6
Airports	180	469
Light Rail Facilities	0	0
Light Rail Bridges	0	0
Utility Facilities		
Communication Facilities	418	15,341
Electric Power Facilities	78	1,425
Natural Gas Facilities	81	368
Oil Facilities	17	112
Potable Water Facilities	30	30
Waste Water Facilities	299	410
High Potential Loss Facilities		
Dams	2,101	2,220
Hazardous Materials Facilities	2,199	3,360
Levees	0	0
Nuclear Power Facilities	3	3

Table 2: Arkansas Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	93	103
Schools	1,059	1,254
Fire Stations	435	1,330
Police Stations	378	515
Emergency Operation Centers	11	11
Transportation Facilities		
Highway Bridges	5,634	5,634
Highway Tunnels	2	2
Railway Bridges	48	48
Railway Facilities	68	68
Railway Tunnel	0	0
Bus Facilities	16	16
Port Facilities	99	99
Ferry Facilities	1	1
Airports	216	314
Light Rail Facilities	0	0
Light Rail Bridges	0	0
Utility Facilities		
Communication Facilities	310	625
Electric Power Facilities	31	56
Natural Gas Facilities	97	97
Oil Facilities	10	10
Potable Water Facilities	69	69
Waste Water Facilities	411	411
High Potential Loss Facilities		
Dams	1,173	1,173
Hazardous Materials Facilities	1,475	1,475
Levees	0	0
Nuclear Power Facilities	1	1

Table 3: Illinois Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	227	249
Schools	5,283	5,722
Fire Stations	1,007	1,725
Police Stations	866	1,044
Emergency Operation Centers	149	149
Transportation Facilities		
Highway Bridges	22,854	22,854
Highway Tunnels	0	0
Railway Bridges	963	1,030
Railway Facilities	285	285
Railway Tunnel	0	4
Bus Facilities	101	119
Port Facilities	438	514
Ferry Facilities	2	11
Airports	624	929
Light Rail Facilities	0	401
Light Rail Bridges	38	38
Utility Facilities		
Communication Facilities	518	34,833
Electric Power Facilities	153	2,172
Natural Gas Facilities	62	1,333
Oil Facilities	39	275
Potable Water Facilities	242	242
Waste Water Facilities	876	9,389
High Potential Loss Facilities		
Dams	1,255	1,511
Hazardous Materials Facilities	4,870	7,249
Levees	0	0
Nuclear Power Facilities	7	7

Table 4: Indiana Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	128	175
Schools	2,630	2,686
Fire Stations	605	1,210
Police Stations	502	474
Emergency Operation Centers	51	51
Transportation Facilities		
Highway Bridges	16,505	16,505
Highway Tunnels	0	0
Railway Bridges	80	92
Railway Facilities	91	91
Railway Tunnel	0	8
Bus Facilities	32	46
Port Facilities	84	91
Ferry Facilities	0	0
Airports	496	496
Light Rail Facilities	0	13
Light Rail Bridges	0	0
Utility Facilities		
Communication Facilities	386	21,679
Electric Power Facilities	54	792
Natural Gas Facilities	29	29
Oil Facilities	11	170
Potable Water Facilities	96	96
Waste Water Facilities	446	446
High Potential Loss Facilities		
Dams	1,026	1,163
Hazardous Materials Facilities	3,793	3,793
Levees	0	0
Nuclear Power Facilities	0	0

Table 5: Kentucky Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	121	135
Schools	1,666	1,846
Fire Stations	625	1,066
Police Stations	381	407
Emergency Operation Centers	9	0
Transportation Facilities		
Highway Bridges	6,443	6,805
Highway Tunnels	4	4
Railway Bridges	143	166
Railway Facilities	117	117
Railway Tunnel	1	18
Bus Facilities	21	26
Port Facilities	277	301
Ferry Facilities	1	16
Airports	142	219
Light Rail Facilities	0	0
Light Rail Bridges	0	0
Utility Facilities		
Communication Facilities	374	16,357
Electric Power Facilities	68	1,693
Natural Gas Facilities	75	337
Oil Facilities	20	88
Potable Water Facilities	179	179
Waste Water Facilities	335	9,080
High Potential Loss Facilities		
Dams	1,134	1,188
Hazardous Materials Facilities	2,060	2,830
Levees	0	0
Nuclear Power Facilities	0	0

Table 6: Mississippi Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	105	123
Schools	1,124	1,281
Fire Stations	430	984
Police Stations	368	365
Emergency Operation Centers	37	37
Transportation Facilities		
Highway Bridges	13,692	16,936
Highway Tunnels	0	0
Railway Bridges	56	63
Railway Facilities	71	76
Railway Tunnel	1	1
Bus Facilities	27	40
Port Facilities	205	222
Ferry Facilities	0	2
Airports	192	256
Light Rail Facilities	0	0
Light Rail Bridges	0	0
Utility Facilities		
Communication Facilities	299	9,216
Electric Power Facilities	32	748
Natural Gas Facilities	55	415
Oil Facilities	10	105
Potable Water Facilities	17	17
Waste Water Facilities	335	3,080
High Potential Loss Facilities		
Dams	3,307	3,514
Hazardous Materials Facilities	1,154	1,939
Levees	0	0
Nuclear Power Facilities	1	1

Table 7: Missouri Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	143	160
Schools	2,863	2,817
Fire Stations	636	1,399
Police Stations	592	654
Emergency Operation Centers	33	33
Transportation Facilities		
Highway Bridges	21,765	21,765
Highway Tunnels	0	0
Railway Bridges	163	200
Railway Facilities	125	125
Railway Tunnel	0	12
Bus Facilities	62	72
Port Facilities	193	230
Ferry Facilities	1	8
Airports	401	558
Light Rail Facilities	0	17
Light Rail Bridges	0	0
Utility Facilities		
Communication Facilities	397	20,872
Electric Power Facilities	79	1,406
Natural Gas Facilities	9	354
Oil Facilities	10	119
Potable Water Facilities	187	8,599
Waste Water Facilities	1,312	1,312
High Potential Loss Facilities		
Dams	4,108	5,265
Hazardous Materials Facilities	2,113	2,833
Levees	0	0
Nuclear Power Facilities	1	1

Table 8: Tennessee Inventory Comparison

Infrastructure Category	HAZUS MR2 Default Inventory	Updated Inventory
Essential Facilities		
Hospitals	135	180
Schools	1,973	2,309
Fire Stations	565	1,110
Police Stations	425	423
Emergency Operation Centers	36	0
Transportation Facilities		
Highway Bridges	5,298	7,215
Highway Tunnels	5	5
Railway Bridges	122	151
Railway Facilities	129	129
Railway Tunnel	0	15
Bus Facilities	35	51
Port Facilities	168	200
Ferry Facilities	1	6
Airports	184	315
Light Rail Facilities	0	25
Light Rail Bridges	0	0
Utility Facilities		
Communication Facilities	458	16,130
Electric Power Facilities	59	428
Natural Gas Facilities	56	183
Oil Facilities	21	121
Potable Water Facilities	98	98
Waste Water Facilities	504	1,946
High Potential Loss Facilities		
Dams	994	1,204
Hazardous Materials Facilities	2,489	4,006
Levees	0	0
Nuclear Power Facilities	2	2

Appendix III: Fragility Relationships[1]

Overview

Fragility relationships are a critical component of seismic impact assessment. The fragility, or vulnerability, functions relate the severity of shaking to the probability of reaching a level of damage (e.g. light, medium, extensive, near-collapse) to various infrastructure items. The level of shaking can be quantified using numerous shaking parameters, including peak ground acceleration, velocity, displacement, spectral acceleration, spectral velocity or spectral displacement. Each infrastructure item requires a corresponding set of fragilities to determine damage level likelihoods (probability). For example, medium span RC bridges will have 3 fragility relationships that yield the likelihood that a bridge will be lightly damaged, incur medium damage or be near collapse. All inventory categories provided in HAZUS-MH MR2 also include fragilities, termed 'default' fragilities as they are the default values used by the program. It is possible to improve these fragilities for more accurate impact assessments. Due to the tight time line for the emergency response planning workshops for the 8 states, the HAZUS default fragilities were used throughout this study. Phase II of the current project will employ advanced fragilities based on analytical and physical simulations.

Each infrastructure type has a set of fragility functions—one for each damage level. HAZUS-MH MR2 specifies four damage levels: slight, moderate, extensive, and complete. Complete damage is most simply defined as being damaged beyond any state of repair. All other damage states vary between no damage up to complete damage, though descriptions for each infrastructure type differ based on the type of construction. When fragility functions are updated, the parameters for each of the four damage levels must be updated. Many default fragilities are based on expert opinion, and updating these with fragilities developed using analytical models will improve the accuracy of damage estimations. Since inventory and hazard improvements were the primary components of this series of Phase I analyses, fragility functions were not updated. Default fragilities are considered conservative since very little analytical work was done to generate most of them. As a result, improving fragilities does not always increase damage, as shown by Elnashai and Cleveland (2007).

Fragility Definition and Applications

In general, fragility functions relate a level of shaking, or system demand, to the conditional probability of a specific system reaching or exceeding a limit state response. Figure 1 illustrates typical fragility functions. A deterministic response, or the vertical line, indicates a lack of uncertainty in the system response. Fragility curves close to vertical indicate a low level of uncertainty (P1), while those with a much higher uncertainty are spread over a much wider range of shaking values (P2).

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[1] This appendix heavily references the Illinois Emergency Management Agency Report (Mid-America Earthquake Center, 2007).

Derivation of useful functions requires the definition of limit states that are meaningful in the context of loss assessment. Selection and quantitative definition of limit states are central to the derivation of system vulnerability. With the limit states already defined, the limit state probability is given by:

$$P[LS] = \Sigma P[LS \mid D = d] P[D = d] \qquad (1)$$

Here D defines the random variable representing the demand of the system; P[LS|D=d] is the conditional limit state probability, given that D=d, and the summation taken over all values of D. The probability P[D=d] defines the hazard. The variable d is the control or interface variable.

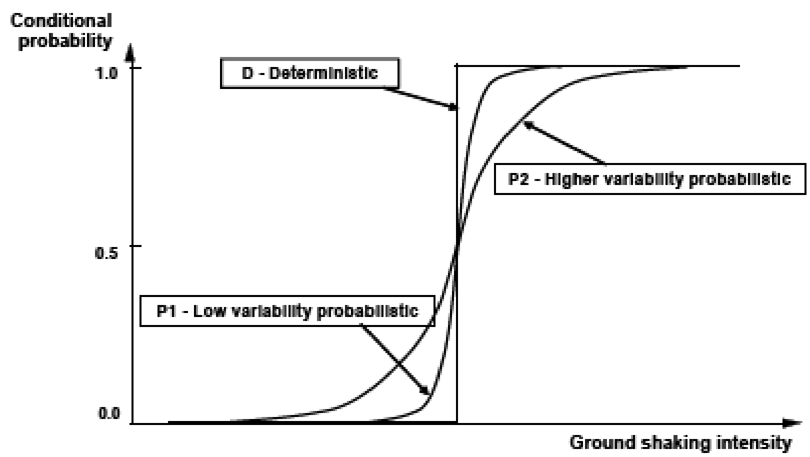

Figure 1: Typical Fragility Function

The conditional probability, P[LS|D=d] = V(x), is the measure of vulnerability (Wen et al, 2003). The previous equation indicates a coupled probabilistic approach, meaning coupled with regard to the system resistance or limit states and demand imposed on the system. Conversely, uncoupled vulnerability analysis, indicating that relationships are derived which are independent of the site hazard, offer a number of attractive features, such as simplification of the derivations and avoidance of the need to define very low probability events (Wen et al, 2003).

Default HAZUS-MH MR2 Fragilities for Buildings

HAZUS-MH MR2 classifies buildings into 36 different types based on the building material and structural system employed in the building's construction. A summary of building types is illustrated in Table 1, while more detailed descriptions are provided the HAZUS-MH MR2 Technical Manual (FEMA-NIBS, 2006). The inventory in the regions considered in the NMSZ analysis only includes 16 of these 36 building types. Mid-rise and high-rise buildings are not part of the HAZUS-MH MR2 building inventory in the central and eastern US (CEUS).

The 16 building types that comprise the eight state regions investigated in this study include:

- W1
- W2
- S1L
- S2L
- S3
- S4L
- S5L
- C1L
- C2L
- C3L
- PC1
- PC2L
- RM1L
- RM2L
- URML
- MH

Building fragilities are based on the spectral displacement shaking parameter. A typical set of fragility curves for buildings is displayed in Figure 2. Each of the four damage states utilized in HAZUS-MH MR2 is represented in the figure.

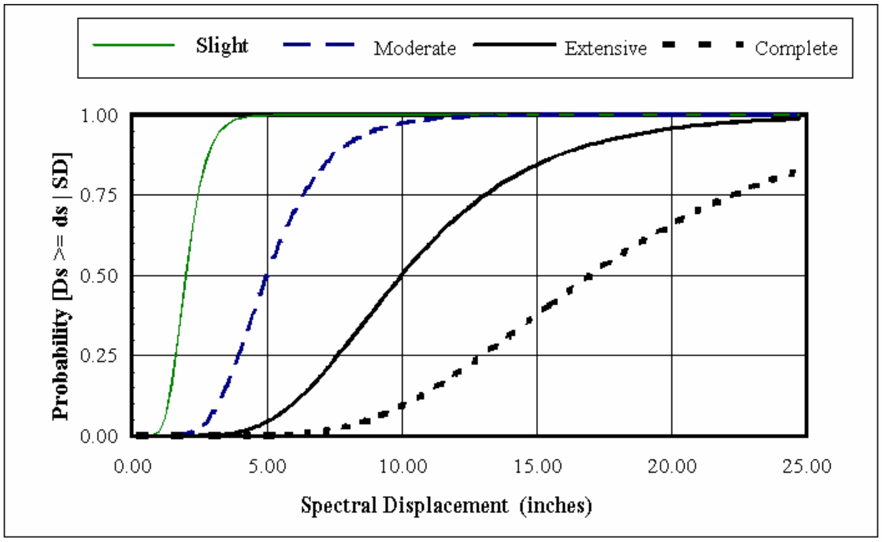

Figure 2: Example Set of Fragility Curves for Buildings

Fragility curves are developed using the equation below:

$$P[Exceedance_i \mid S_d] = \Phi\left[\frac{1}{\beta_{TOTi}}\ln\left(\frac{S_d}{LS_i}\right)\right] \quad (2)$$

Where: Φ = Standard Normal Cumulative Distribution function;
β_{TOTi} = Total uncertainty associated with damage state, I;
S_d = Spectral displacement (variable);
LS_i = Median value of spectral displacement at which the building reaches the threshold of damage state, i

In order to utilize the fragility relationships which provide the damage probabilities as a function of the structural response, the latter must first be determined using a capacity spectrum approach. This requires the definition of building capacity curves for the four seismic design levels; pre-, low-, moderate-, and high-code; of the 36 building types (36x4 curves).

Table 1: Model Building Types

No.	Label	Description	Height			
			Range		Typical	
			Name	Stories	Stories	Feet
1	W1	**Wood, Light Frame (≤ 5,000 sq. ft.)**		1 - 2	1	14
2	W2	**Wood, Commercial and Industrial (> 5,000 sq. ft.)**		All	2	24
3	S1L	**Steel Moment Frame**	Low-Rise	1 - 3	2	24
4	S1M		Mid-Rise	4 - 7	5	60
5	S1H		High-Rise	8+	13	156
6	S2L	**Steel Braced Frame**	Low-Rise	1 - 3	2	24
7	S2M		Mid-Rise	4 - 7	5	60
8	S2H		High-Rise	8+	13	156
9	S3	**Steel Light Frame**		All	1	15
10	S4L	**Steel Frame with Cast-in-Place Concrete Shear Walls**	Low-Rise	1 - 3	2	24
11	S4M		Mid-Rise	4 - 7	5	60
12	S4H		High-Rise	8+	13	156
13	S5L	**Steel Frame with Unreinforced Masonry Infill Walls**	Low-Rise	1 - 3	2	24
14	S5M		Mid-Rise	4 - 7	5	60
15	S5H		High-Rise	8+	13	156
16	C1L	**Concrete Moment Frame**	Low-Rise	1 – 3	2	20
17	C1M		Mid-Rise	4 - 7	5	50
18	C1H		High-Rise	8+	12	120
19	C2L	**Concrete Shear Walls**	Low-Rise	1 - 3	2	20
20	C2M		Mid-Rise	4 - 7	5	50
21	C2H		High-Rise	8+	12	120
22	C3L	**Concrete Frame with Unreinforced Masonry Infill Walls**	Low-Rise	1 - 3	2	20
23	C3M		Mid-Rise	4 - 7	5	50
24	C3H		High-Rise	8+	12	120
25	PC1	**Precast Concrete Tilt-Up Walls**		All	1	15
26	PC2L	**Precast Concrete Frames with Concrete Shear Walls**	Low-Rise	1 - 3	2	20
27	PC2M		Mid-Rise	4 - 7	5	50
28	PC2H		High-Rise	8+	12	120
29	RM1L	**Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms**	Low-Rise	1-3	2	20
30	RM1M		Mid-Rise	4+	5	50
31	RM2L	**Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms**	Low-Rise	1 - 3	2	20
32	RM2M		Mid-Rise	4 - 7	5	50
33	RM2H		High-Rise	8+	12	120
34	URML	**Unreinforced Masonry Bearing Walls**	Low-Rise	1 - 2	1	15
35	URMM		Mid-Rise	3+	3	35
36	MH	**Mobile Homes**		All	1	10

Pushover curves are generally obtained from experimental results in published literature or through analytical models of specific structure types. Pushover curves are often represented as a roof displacement versus a total base shear. These units are not compatible with the units of HAZUS-MH MR2 building fragilities (in units of spectral displacement, S_d) and must be converted according to the following:

$$S_a = \frac{V/W}{\alpha_1} \qquad (3)$$

$$\alpha_1 = \frac{\left[\sum_{i=1}^{N} w_i\phi_{i1}/g\right]^2}{\left[\sum_{i=1}^{N} w_i/g\right]\left[\sum_{i=1}^{N} \left(w_i\phi_{i1}^{\ 2}\right)/g\right]} \qquad (4)$$

$$S_d = \frac{\Delta_{roof}}{PF_1\phi_{roof,1}} \qquad (5)$$

$$PF_1 = \left[\frac{\sum_{i=1}^{N} \left(w_i\phi_{i1}\right)/g}{\sum_{i=1}^{N} \left(w_i\phi_{i1}^{\ 2}\right)/g}\right] \qquad (6)$$

Equation (3) converts base shear into spectral acceleration while equation (5) converts roof displacement into spectral displacement. Parameters α_1 and PF_1 are provided in equations (4) and (6), respectively. In these equations, w_i denotes the weight of a single story, and φ_{i1} denotes the value of the fundamental mode shape at story i. Please refer to the Applied Technology Council Report, ATC-40, from 1996 for further information on this procedure.

The HAZUS-MH MR2 procedure for constructing capacity curves does not rely on analytical models, but rather uses the following parameters:

- C_s is the design strength coefficient (fraction of building's weight)
- T_e is the expected 'elastic' fundamental-mode period of the building (seconds)
- α_1 is the fraction of building weight effective against the pushover mode
- γ is the 'over-strength' factor relating 'true' yield strength to design strength
- λ is the 'over-strength' factor relating ultimate strength to yield strength
- μ is the 'ductility' ratio relating ultimate displacement to λ times the yield displacement

The first two parameters are determined using 1994 NEHRP Provisions, while the remaining parameters rely on the best estimates of typical design properties. These parameters can be found in Tables 5.4, 5.5 and 5.6 of the HAZUS-MH MR2 Technical Manual, Chapter 5.

The control points, or yield and ultimate points, can be determined using the equations provided in Figure 3, and capacity curves can be constructed from these points. The relationship between spectral acceleration and displacement is constant until the yield point. After the ultimate point, spectral acceleration is constant, and this region is connected to the linear portion with a nonlinear relationship between spectral values.

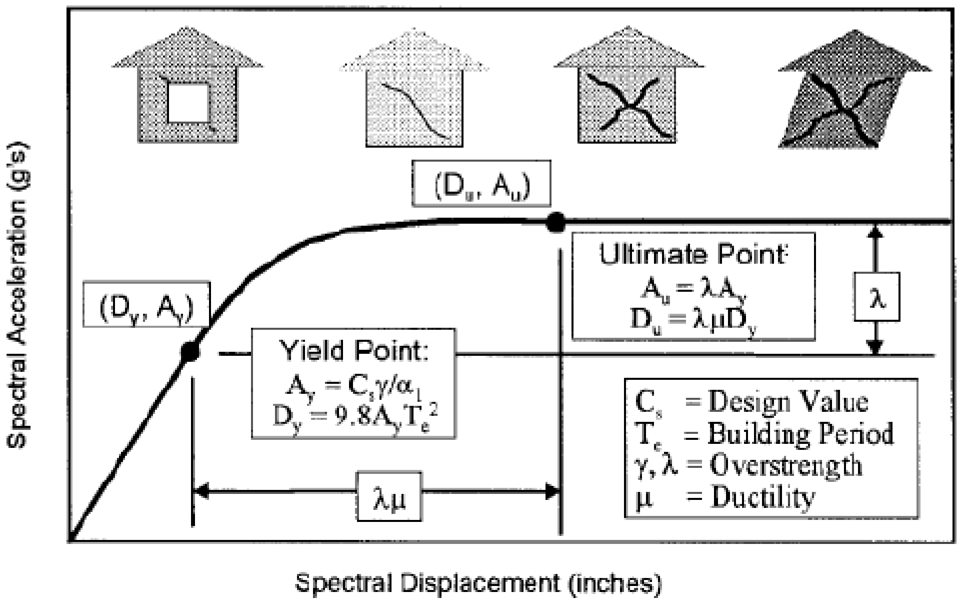

Figure 3: Derivation of Capacity Curves

Threshold values for each of the damage states are determined using the capacity curves and the NEHRP Guidelines in FEMA 273 (1997). The following engineering criteria are established for different design levels and heights of the same construction type:

- Values of the drift ratio that define Complete damage to Moderate-Code buildings are assumed to be 75% of the drift ratio that define Complete damage to High-Code buildings, and values of the drift ratio that define Complete damage to Low-Code buildings are assumed to be 63% of the drift ratios that define Complete damage to High-Code buildings. Values of drift ratio that define Slight damage were assumed to be the same for High-Moderate-Low-Code buildings, given that this damage state typically does not exceed the building's elastic capacity. For each damage state, the drift ratio of a Pre-Code building is of the same building type.
- For all damage states, drift ratios for mid-rise buildings are assumed to be 67% of those for low-code buildings of the same type, and drift ratios for high-rise buildings are assumed to be 50% of those of low-rise buildings of the same type. Drift values can be converted to spectral displacement values using equation (5). An example showing the locations of damage state thresholds on the capacity curves is shown in Figure 4.

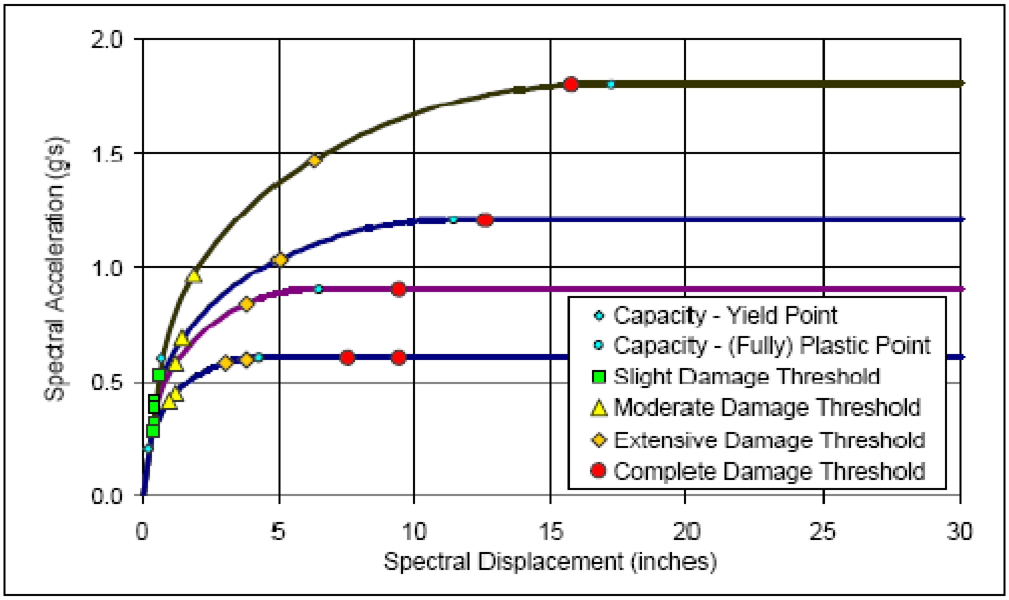

Figure 4: Capacity Curves and Damage State Thresholds for the Building Type W1

The total uncertainty, β_{TOT}, is required to draw the fragility curves for each building type. This parameter is required for each damage state and is given by the following equation:

$$\beta_{TOT} = \sqrt{\left(CONV[\beta_C, \beta_D]^2 + (\beta_{LS})^2\right)} \qquad (7)$$

Where β_C = the lognormal standard deviation parameter that describes the total variability of the capacity curve

β_D = the lognormal standard deviation parameter that describes the variability of the demand spectrum

β_{LS} = the lognormal standard deviation parameter that describes the uncertainty in the estimate of the median value of the threshold of the associated structural damage state

The β_C term is set to 0.25 for all code-level buildings and 0.3 for pre-code buildings. The β_{LS} term is set to 0.4 of all structural damage states and building types. The β_D term is set to 0.45 for short periods and 0.5 for long periods. The term *CONV[β_C, β_D]* indicates the convolution of the uncertainty associated with the capacity and demand terms. This process is required to combine the uncertainty in capacity and demand as they are not independent of each other. This means that a change in capacity affects the demand imposed, and the demand imposed on the structure affects the capacity (for non-linear analysis).

The convolution process permits the determination of building performance when subjected to ground motion. This is accomplished with the capacity spectrum method (CSM), a non-linear static analysis procedure. The documentation of this procedure can be found in Freeman et al (1975), Freeman (1978), and later in ATC-40 (1996) and FEMA 274 (1997). HAZUS-MH MR2

uses an iterative process with capacity and demand curves to find the performance point. As an example, fragility curves for W1 (including the seismic design level) are shown in Figure 5.

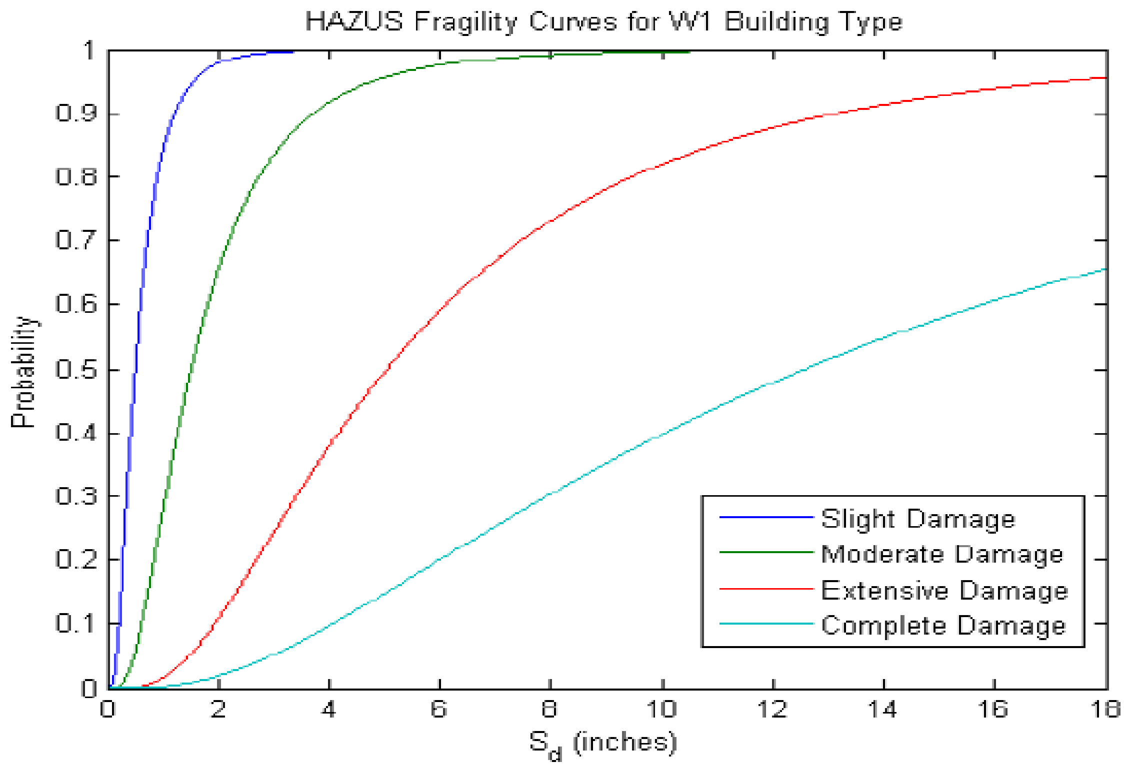

Figure 5: Fragility Curves for W1 Buildings

Though not explained herein, the remaining inventory types utilize the default fragilities in HAZUS-MH MR2. All fragility parameters for the remaining inventory types can be found in the HAZUS-MH MR2 Technical Manual. Updating fragilities will be a major component of all Regional level analyses, particularly focusing on wood frame building fragilities and bridge fragilities.

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Appendix IV: Earthquake Impact Assessment Methodology

The earthquake impact assessment completed by the Mid-America Earthquake Center and the George Washington University exclusively uses HAZUS-MH MR2 (future analyses will employ HAZUS and MAEviz, the MAE Center advanced impact assessment, management and decision-making software package). HAZUS-MH MR2 was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). Originally designed for mitigation purposes, the software is now used for response planning, emergency managers, building officials, local governments, insurance agencies, and research institutions. There are numerous methods of refining an analysis in HAZUS-MH MR2, and each user must determine the level of refinement and accuracy that is required for the analysis undertaken.

In general, an analysis requires three primary components: hazard, inventory, and fragility. Hazard definition consists not only of ground shaking but also ground deformation. Inventory includes all relevant infrastructure types, their locations, building types, and replacement costs. Finally, fragility relates the level of ground shaking to a likelihood of specific severity levels of damage. Each of these components is detailed in other appendices in this report. Please consult these appendices for more information on hazard, inventory, and fragility. This comprises the direct infrastructure damage in a region of interest. The direct damage calculations are then used to determine both direct and indirect induced damage, social impacts, and economic losses.

Level of Analysis in HAZUS-MH MR2

A Level I analysis is the most basic form of analysis in HAZUS-MH MR2. This type of analysis can be run without any improvements to the program itself or improvements to the inventory included with the program. Once a region of interest is chosen, the definition of hazard is chosen from the options provided in the program. A hazard may be deterministic or probabilistic. A deterministic hazard refers to a single event from which damage estimates are generated. A probabilistic hazard requires a return period and magnitude for the desired earthquake. Results are provided in terms of annualized losses instead of total losses from an event. The deterministic hazard is utilized exclusively in this report. There are several methods available in HAZUS-MH MR2 for a Level 1 hazard definition, including an arbitrary event in which magnitude and depth to the epicenter are specified and a historical event from the database is provided in the program. This level of analysis does not consider the effects of soil amplification and ground deformation. Neither inventory updates nor improvements to fragility relationships are required.

Various improvements are required to run a Level II analysis. Some improvement to the hazard is one critical facet of a Level II analysis. This includes such steps as improving the method of defining ground motion, the addition of soil amplification, the addition of liquefaction susceptibility to model ground deformation, and landslide susceptibility. Inventory improvements are also required and may include updates to critical facilities such as schools, hospitals, bridges, and utility facilities and networks, or the updating of demographic data. Updates to fragility functions are also classified as Level II improvements. It would be difficult

to update all fragilities to all infrastructure types, due to the general lack of research in some areas. Buildings, bridges, and certain utility networks are common in the literature and may be the easiest to locate and update in HAZUS-MH MR2.

The most advanced analysis in HAZUS-MH MR2 is a Level II analysis. This type of analysis requires more time and effort to complete. Detailed engineering and economic loss studies may be completed. Site-specific investigations are also recommended at this stage of refinement. The use of the Advanced Engineering Building Module (AEBM) is available to import and assess damage for new types of buildings. Very few earthquake impact assessments reach this level of analysis, due to the time required. An example of an AEBM analysis was undertaken by Erberik and Elnashai (2006) for flat slab structures, a system that is not featured in the HAZUS building types.

HAZUS-MH MR2 Modules

The earthquake impact assessment in HAZUS-MH MR2 is carried out in numerous steps, or modules. Each type of damage, loss, or impact calculation generally has its own module. Many of the modules used in HAZUS-MH MR2 are detailed in the following discussion. It is possible for a user to select only certain modules in a specific analysis. For a comprehensive assessment, however, all modules are recommended. This includes all damage and losses for buildings, transportation and utility systems, as well as induced damage and social impacts.

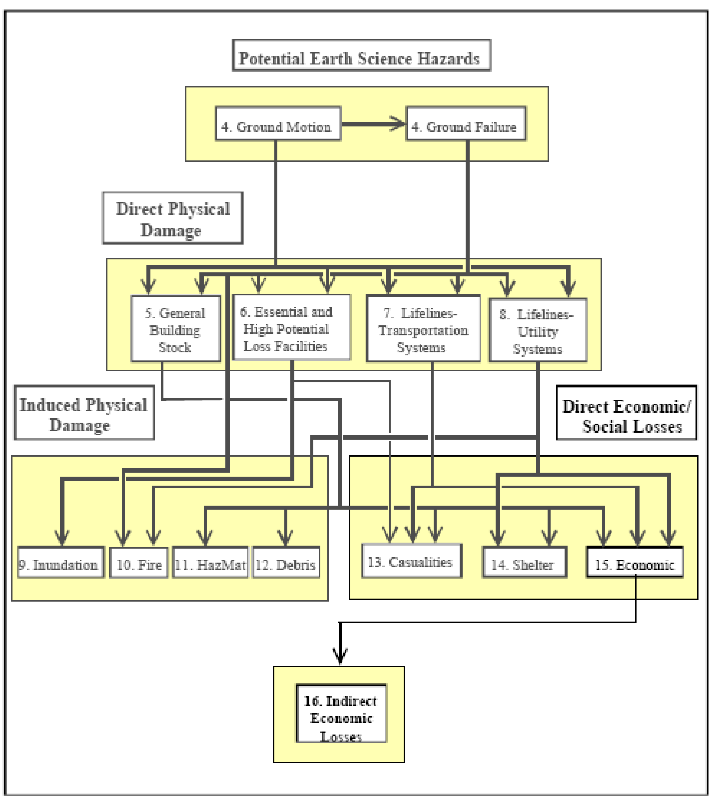

Figure 1: HAZUS-MH MR2 Earthquake Impact Assessment Methodology

Potential Earth Science Hazard Module

The potential earth science hazard module includes the estimation of ground motion and ground failure, including liquefaction, landslides, and surface fault rupture. A minimum definition of hazard requires that the level of shaking be quantified over the entire region of interest, expressed as peak ground motion parameters (acceleration, velocity, and displacement). The hazard may also be expressed as peak response of simple structures (peak spectral values: peak spectral acceleration, velocity, and displacement). Attenuation relationships are the simplest method for determining ground motion and modeling a point-source event. Line-source modeling involves the rupture of an entire fault segment and may account for directionality of fault rupture in the estimation of ground motion. By including more aspects of ground motion, line-source modeling is preferred to a more simplified point-source model. Area source models also exist, and require considerable knowledge of the tectonic environment and mapping of fault geometry and likely mechanisms of rupture. For user-supplied ground motion, the internal ground motion calculation is not considered.

Ground failure parameters, such as liquefaction susceptibility, are culled from maps. Soil amplification is used to adjust the ground motion for local soil conditions. For example, soft soil deposits are likely to filter short period vibrations and amplify long period shaking, thus increasing the likelihood of damage to long period structures, such as high-rise buildings and long-span bridges. Liquefaction susceptibility refers to the change in phase of partially saturated soil deposits that may completely lose cohesion during prolonged shaking. This results in permanent ground deformations such as lateral spreading and settlement, both of which increase the likelihood of damage to infrastructure. Landslide susceptibility is included in earthquake impact assessments in order to define the likelihood of inclined deposits sliding during or shortly after earthquakes.

Inventory Module

The inventory utilized in HAZUS-MH MR2 includes the general building stock, essential facilities, transportation lifelines, utility lifelines, and high potential-loss facilities. The general building stock is not a collection of individual buildings but rather an estimated value of buildings in a given census tract. These estimates are based on population demographics, which factor into estimates of building counts and building uses. Building occupancy classes are used to categorize buildings by use. There are 33 occupancy classes in HAZUS-MH MR2 and 36 building types that categorize the structural system used in buildings. For more information on building types and occupancy classes, please refer to the HAZUS-MH MR2 Technical Manual, Chapter 5. In addition, square footage estimates are provided at the census tract level for the general building stock.

Critical facilities are included in the inventory module as individual data items. Critical facilities include essential facilities such as schools, emergency operation centers, hospitals, police stations and fire stations. Transportation lifelines include highway bridges and roads, railway bridges, facilities and tracks, airports, bus terminals, ports, and ferry facilities. Utility lifelines include waste water facilities and local distribution networks, potable water facilities and local distribution networks, natural gas facilities and local networks, as well as oil, electric power, and

communication facilities. For some levels of analysis, regional distribution networks may be added.

Direct Damage Module

The direct damage module uses the inventory and the potential earth science hazard to estimate damage for each inventory component. The damage results are given as a probability of reaching each of the four damage states: slight, moderate, extensive, and complete. The damage for each inventory item is described by a fragility (or vulnerability) function, which indicates the probability of damage based on an input ground motion hazard parameter. Both structural and nonstructural damage are approximated for the general building stock.

Induced Damage Module

The induced damage modules available in HAZUS-MH MR2 include debris generation, fire following earthquake, and inundation from dam failure. Dam failure and inundation are not included in this report due to the lack of inundation maps available. The fire following earthquake (FFE) estimates are not reported since the model for FFE is not regionally appropriate. The model was developed for an urban area, which is dissimilar to much of the NMSZ. Additionally, the module tends to produce fire ignitions in areas of high building density even if shaking and damage are non-existent and considered erroneous. The debris generation module is the only induced damage module utilized in this report and is determined based on building square footage in a census tract.

Direct Social Loss Module

This module includes estimates of casualties, displaced households, and temporary shelter requirements. Casualty estimates are generated for three times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times of day are designed to represent various population locations, meaning when people are at home sleeping, at work, and commuting. Casualty estimates are divided into four severity levels as follows, along with Simple Triage and Rapid Treatment (START) classifications:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated
- Severity Level 4 (Black): Victims are killed as a result of the earthquake

Casualties estimated are based on structural and nonstructural damage to buildings and do not consider induced damage caused by fire, car accidents, or other medical problems such as heart attacks related to stress. Casualties from secondary hazards are not considered and may include landslides, tsunamis, and dam failures. The HAZUS-MH MR2 casualty model classifies three different types of data:

- Scenario Time Definition
- Data Supplied by Other Modules
- Data Specific to the Casualty Module

The first item accounts for the distribution of the population at the three different times of day: 2:00 AM, 2:00 PM, and 5:00 PM. In general, casualties are expected to be greatest when an earthquake occurs during the night, when people are home in bed. This is not always the case, however, as is shown in some state analyses in this report.

The data supplied by other modules includes population distribution data, building stock inventory, and damage probabilities. The population distribution data is taken from the U.S. Census Bureau and from Dun and Bradstreet business data. The population is then divided into six categories, in which population percentages vary throughout the day:

1) Residential Population
2) Commercial Population
3) Educational Population
4) Industrial Population
5) Commuting Population
6) Hotel Population

Additionally, casualties are divided into categories for indoor and outdoor casualties. The basic framework for indoor casualties is shown in Figure 2. This model integrates various casualty severity levels with the occupancy types in HAZUS-MH MR2. A similar framework exists for outdoor casualties, though it is not shown here. Indoor and outdoor casualties are combined for a total estimate of casualties.

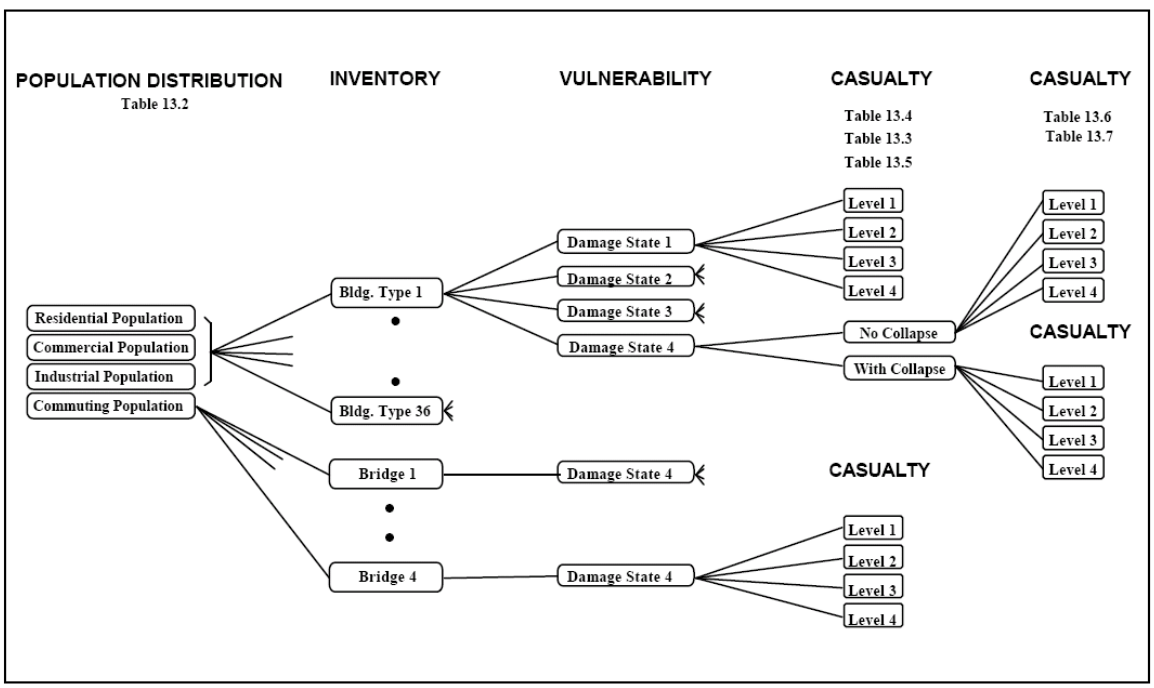

Figure 2: Indoor Casualty Event Tree

Displaced Households[1]

The estimation of displaced households takes into consideration occupancy classes for residential buildings. While HAZUS-MH MR2 classifies residential buildings by the occupancy classes shown in Table 1, only RES1 and RES3 classes are considered in the calculation of displaced households.

Table 1: HAZUS-MH MR2 Residential Building Types

RES1	Single Family Dwelling
RES2	Mobile Home
RES3A	Multi Family Dwelling – Duplex
RES3B	Multi Family Dwelling – 3-4 Units
RES3C	Multi Family Dwelling – 5-9 Units
RES3D	Multi Family Dwelling – 10-19 Units
RES3E	Multi Family Dwelling – 20-49 Units
RES3F	Multi Family Dwelling – 50+ Units
RES4	Temporary Lodging
RES5	Institutional Dormitory
RES6	Nursing Home

The HAZUS-MH MR2 technical manual provides the following formulas for the calculation of Displaced Households. Table 2 provides the definition of the variables used in the formulas.

$$SF_{\%} = w_{SFM} SFM_{\%} + w_{SFE} SFE_{\%} + SFC_{\%}$$
$$MF_{\%} = w_{MFM} MFM_{\%} + w_{MFE} MFE_{\%} + MFC_{\%}$$
$$DH_{\#} = \left(SF_{\#} SF_{\%} + MF_{\#} MF_{\%} \right) \left(\frac{HH_{\#}}{SF_{\#} + MF_{\#}} \right)$$

[1] Examination of the outputs for displaced population found that the calculations being performed within HAZUS-MH MR2 were incorrect due to errors in the software. This is currently being corrected in the next release of the software. To calculate these estimates for the scenarios discussed in this report, we combined the damage estimates and population estimates from HAZUS-MH MR2 and utilized the HAZUS-MH MR2 methodology to derive the number of displaced people.

Table 2: Definition of Variables Used in Displaced Household Calculations

$SFU_{\#}$	Total Number of Single-Family Dwelling Units
$MFU_{\#}$	Total Number of Multi-Family Dwelling Units
$HH_{\#}$	Total Number of Households
$SFM_{\%}$	Damage state probability for moderate structural damage in the single-family residential occupancy class
$SF_{\%}$	Damage state probability for extensive structural damage state in the single-family residential occupancy class
$SFC_{\%}$	Damage state probability for complete structural damage state in the single-family residential occupancy class
$MFM_{\%}$	Damage state probability for moderate structural damage state in the multi- family residential occupancy class
$MFE_{\%}$	Damage state probability for extensive structural damage state in the multi- family residential occupancy class
$MFC_{\%}$	Damage state probability for complete structural damage state in the multi- family residential occupancy class

HAZUS-MH MR2 calculates the damage probabilities based on structural building type and not occupancy class. HAZUS-MH MR2 then uses these structural damage probabilities, along with occupancy mapping (which structural building types are used for specific occupancy classes, including percentage), to calculate the number of damaged buildings per occupancy class. These in turn can be used to calculate the damage probabilities for the occupancy classes. For multifamily housing there is no data on average occupancy rates available. The classification of the RES3 classes provides ranges for the units in a dwelling; therefore the mappings in Table 3 were used in the calculations.

Table 3: Mapping of Residential Building Type to Number of Units

Type	Description	Units
RES1	Single Family Dwelling	1
RES2	Mobile Home	1
RES3A	Multi Family Dwelling – Duplex	2
RES3B	Multi Family Dwelling – 3-4 Units	4
RES3C	Multi Family Dwelling – 5-9 Units	7
RES3D	Multi Family Dwelling – 10-19 Units	15
RES3E	Multi Family Dwelling – 20-49 Units	35
RES3F	Multi Family Dwelling – 50+ Units	75

The following damage weight factors provided by HAZUS-MH MR2 were also utilized.

- 100% of the households living in completely damaged RES1 and RES2 buildings are considered displaced
- 100% of the households living in completely damaged RES3 buildings are considered displaced
- 90% of the households living in extensively damaged RES3 buildings are considered displaced
- All other households will not seek shelter

Shelter Requirements[2]

The HAZUS-MH MR2 methodology is based on the following formula:

$$STP_{\#} = \sum_{i=1}^{5}\sum_{j=1}^{5}\sum_{k=1}^{2}\sum_{l=1}^{3}\left(\alpha_{ijkl}\left(\frac{DH_{\#}POP}{HH_{\#}}\right)HI_i HE_j HO_k HA_l\right)$$

$$\alpha_{ijkl} = \left(IW * IM_i\right) + \left(EW * EM_j\right) + \left(OW * OM_k\right) + \left(AW * AM_l\right)$$ [3]

[2] Examination of the outputs for shelter seeking population found that the calculations being performed within HAZUS-MH MR2 were incorrect due to errors in the software. This is currently being corrected in the next release of the software. To calculate these estimates for the scenarios discussed in this report, we combined the damage estimates and population estimates from HAZUS-MH MR2 and utilized the HAZUS-MH MR2 methodology to derive the number of shelter seeking people.

[3] All weights relevant for the α_{ijkl} calculations are given in the HAZUS-MH MR2 Technical Manual and are also listed in this appendix.

Table 4 provides a definition of the variables used in the above formula.

Table 4: Definition of Variables Used in Shelter Seeking Population Calculations

POP	Number of people in census tract
$HH_{\#}$	Number of Households
HI_1	Percentage of households whose income is under $10,000
HI_2	Percentage of households whose income is $10,001 to $15,000
HI_3	Percentage of households whose income is $15,001 to $25,000
HI_4	Percentage of households whose income is $25,001 to $35,000
HI_5	Percentage of households whose income is over $35,000
HE_1	Percentage of white households
HE_2	Percentage of black households
HE_3	Percentage of Hispanic households
HE_4	Percentage of Native American households
HE_5	Percentage of Asian households
HO_1	Percentage of households owned by householder
HO_2	Percentage of households rented by householder
HA_1	Percentage of population under 16 years old
HA_2	Percentage of population between 16 and 65 years old
HA_3	Percentage of population over 65 years old
$HI\mathrm{i}$	Percentage of population in the i^{th} income class
$HE\mathrm{j}$	Percentage of population in the j^{th} ethnic class
HO_{k}	Percentage of population in the k^{th} ownership class
HA_{l}	Percentage of population in the l^{th} age class
$STP_{\%}$	Number of people requiring short term housing

The number of shelter seeking population is solely based on displaced persons due to structural damage. Severe damage to lifeline systems such as water and electricity might also add to the shelter population. In addition, the consecutive planning numbers do not consider severe damage to lifeline systems. All calculations are performed on census tract level using the Census 2000 data provided by HAZUS-MH MR2. Once calculated on the tract level, the results are aggregated on county level.

The calculation of the shelter seeking population takes into consideration – among other factors – ethnicity, income, and age. The corresponding factors from the shelter algorithm are then used along with census data to calculate the ethnic, income, and age distribution for the calculated number of shelter seeking people. This may drive different planning assumptions. For example, planners might want to plan differently if 90% of the shelter seeking population is of low income.

HAZUS-MH MR2 Parameters for Calculating Shelter Requirements and Displaced Households

Table 5: Demographic Weight Factors

Weight Factor	Description	Importance Factor
AW	Age Weighting Factor	0
EW	Ethnic Weighting Factor	0.27
IW	Income Weighting Factor	0.73
OW	Ownership Weighting Factor	0

Table 6: Demographic Modification Factors

Class	Description	Factor
AM_1	Population Under 16 Years Old	0.4
AM_2	Population Between 16 and 65 Years Old	0.4
AM_3	Population Over 65 Years Old	0.4
EM_1	White	0.24
EM_2	Black	0.48
EM_3	Hispanic	0.47
EM_4	Asian	0.26
EM_5	Native American	0.26
IM_1	Household Income < \$10000	0.62
IM_2	\$10000 < Household Income < \$15000	0.42
IM_3	\$15000 < Household Income < \$25000	0.29
IM_4	\$25000 < Household Income < \$35000	0.22
IM_5	\$35000 < Household Income	0.13
OM_1	Owner Occupied Dwelling	0.4
OM_2	Renter Occupied Dwelling	0.4

Table 7: Damage State Factors

Class	Description	Value
w_{MFC}	Weight for Multi-Family Dwelling - Complete Damage	1
w_{MFE}	Weight for Multi-Family Dwelling - Extensive Damage	0.9
w_{MFM}	Weight for Multi-Family Dwelling - Moderate Damage	0
w_{SFC}	Weight for Single Family Dwelling - Complete Damage	1
w_{SFE}	Weight for Single Family Dwelling - Extensive Damage	0
w_{SFM}	Weight for Single Family Dwelling - Moderate Damage	0

Needs Assessments for Shelter Planning

The estimated shelter seeking population is used to calculate the hazard generated demand for shelter planning. Again, these numbers consider only shelter seeking population due to structural damage. Needs assessments are provided for the following three planning periods: day 1, days 1-3, and days 1-7. The peak shelter population estimate is used to calculate the assessments for all three periods. The following sections explain the calculation parameters.

Table 8 provides the default requirements, values, and source of the value used in the calculations. Note: The default values can be changed for comparison purposes.

Table 8: Needs Assessments for Shelter Seeking Population

Shelter space total • 480 square foot per person (this includes space for all shelter related infrastructure) • Source: The Sphere Project (2004) **Sleeping space** • 60 square foot per person • Source: The Sphere Project (2004), Abou-Samra **Cots and Blankets** • 1 per person • Source: The Sphere Project (2004), Abou-Samra **Toilets** Toilets • 1 toilet per 40 persons • Source: The Sphere Project (2004) **Sinks** • 1 per 80 persons • Source: The Sphere Project (2004) **Garbage** Refuse Containers (30 gallon containers) • 1 for every 50 persons • Source: Abou-Samra, The Sphere Project (2004) **Ice** • 8 pounds of ice per person (1 bag) • Source: USACE (2005) Calculation of truck loads • 5,000 bags / 40,000 pounds per truck • Source: USACE (2005)	**Water** Drinking water: • 1 gallon per person per day • Source: Sphere, Abou-Samra, USACE (2005) Water for washing and personal hygiene: • 2 gallon per person per day • Source: The Sphere Project (2004) Other water requirements (e.g. cooking, etc.): • 2 gallon per person per day • Source: The Sphere Project (2004) Calculation of truck loads • 4750 gallons per truck load • Source: USACE (2005) **Food** Estimated Calories • 2,000 Calories per person day • Source: National Research Council (1989) Fresh Food (if calories are provided by fresh food) • 3 pounds per person per day • Source: The Sphere Project (2004) MRE: • 2 MRE per person per day • Source: USACE (2005) Truck loads for MRE • 21744 MRE per truck load • Source: USACE (2005)

Shelter staffing requirements are highly dependent on the size of the shelters and other planning numbers. For these calculations, we assume an average shelter size of 200 people. The ARC uses detailed staffing algorithms to estimate personnel needs. Here, we simply use averaged numbers based on the ARC calculations for a 200 person shelter. The calculated number includes personnel on different levels (from management to manual labor).

- Staff to run shelters: 10 people
- Staff to feed people: 4 people
- Staff for bulk distribution: 8 people

An estimation of the number of displaced people with the seven most prevalent chronic illnesses is also calculated. By combining estimates of the displaced population and the prevalence of

chronic conditions within a state (DeVol & Bedroussian, 2007), an estimation of the chronic cases of cancer, diabetes, heart disease, hypertension, stroke, mental disorders, and pulmonary conditions was calculated. This estimate gives planners an approximation of the chronic cases that need to be cared for within the displaced population. It is possible that a person may suffer from more than one condition.

Direct Economic Loss Module

Direct economic losses are the economic impacts that result form direct damage to infrastructure. Each of the three main infrastructure categories has direct economic loss estimates: buildings, transportation lifelines, and utility lifelines. Building losses include structural and nonstructural losses, contents losses, and various other capital and business interruption losses. Transportation and utility lifelines include losses of infrastructure value only. No capital stock or business interruption losses are considered. There is a module for indirect economic losses that results from a lack of service and operational capabilities of businesses, in terms of employment and dollar value, though this is not included in this report.

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Appendix V: Detailed Earthquake Impact Assessment Results

The results presented in this appendix are a more comprehensive account of the information contained in the main body of this report. Each state is discussed individually and results are not summed over all states because different scenarios are employed for each. Only damage and functionality losses experienced by infrastructure are explained herein. All social and economic losses caused by damage to infrastructure are dealt with in appendix VI. Damage and loss of functionality are shown for both critical counties and statewide totals. Building damage is detailed by occupancy class. Essential facilities damage and functionality loss are shown for all facility types. Transportation lifeline impacts are illustrated for bridges primarily, though other critical transportation infrastructure types are included. Utility lifelines damage is illustrated with facility and network damage figures. Maps of damage and functionality of various infrastructure components are not illustrated here, though are presented in another appendix. Numerous tables are provided to illustrate damage and functionality levels of various infrastructure items in each state. Additionally, damage and functionality results for both scenarios in Alabama and Indiana are presented herein.

Alabama – New Madrid Seismic Zone Scenario

This earthquake impact assessment includes all 67 counties in the State of Alabama. Alabama is approximately 51,700 square miles and is bordered by Tennessee to the north, Florida and the Gulf of Mexico to the south, Georgia to the east and Mississippi to the west. For the purposes of this analysis, 12 critical counties have been identified in the northwestern portion of the state where shaking is anticipated to be most intense. These critical counties are listed and are a primary focus in this impact assessment:

- Colbert
- Cullman
- Fayette
- Franklin
- Lamar
- Lauderdale
- Lawrence
- Limestone
- Marion
- Morgan
- Walker
- Winston

The New Madrid Seismic Zone scenario for the State of Alabama is comprised of a magnitude 7.7 ($M_w7.7$) event along the southwest segment on the middle fault in the New Madrid fault system. The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS) for the middle fault in the proposed New Madrid Seismic Zone (NMSZ). Each fault line is presumed to consist of three fault segments; northeast, central and southwest. The worst-case scenario for the state of Alabama, the critical counties in particular, is an event on the eastern fault line in the southwest segment. The location of this scenario event is illustrated in Figure 1. For more information on the hazard employed in this scenario please reference Appendix I.

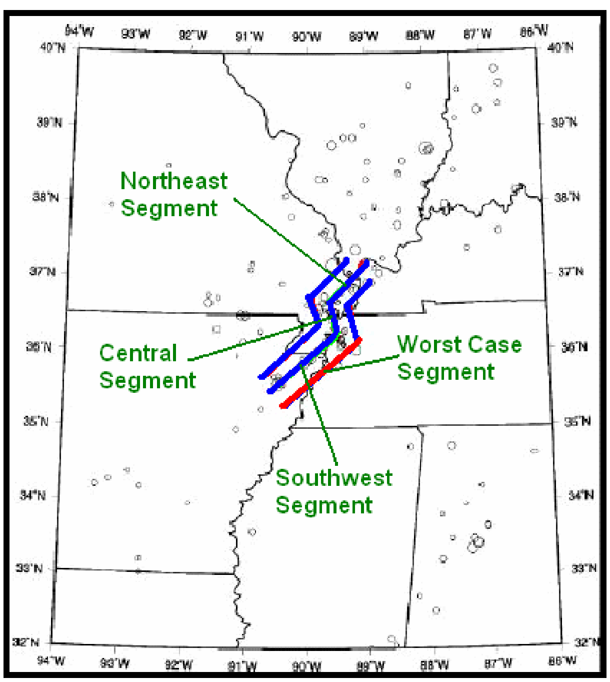

Figure 1: Presumed Seismic Zone Boundaries

Buildings in Alabama are classified in two separate ways for damage estimates; by building use, termed "occupancy," and structure type/material, termed "building type." Damage to Alabama buildings is illustrated in Table 1 and Table 2 for the state and the critical counties, respectively, by occupancy. Residential structures are the most prevalent occupancy type in the State of Alabama and also incur the most cases of damage. Nearly 98% of all moderate and severe damage occurs in single family home and 'other residential' occupancy categories. There are no cases of complete damage which is defined by damage to critical structural connections and significant lateral displacements of structural systems. Cases of partial or complete collapse are rare, though in most cases result in uninhabitable structures. Shaking from a New Madrid event is not as intense as in other states closer to the fault and damage in Alabama, and even the critical counties, is not as catastrophic as a result. For definitions of each damage level please refer Appendix VII.

Table 1: Damage by General Occupancy Type for the State of Alabama

General Occupancy Type Damage (State level)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,303,224	539	0
Other Residential	354,031	5,581	0
Commercial	18,249	119	0
Industrial	2,048	20	0
Other	2,014	9	0
Total	1,679,566	6,268	0

Table 2: Damage by General Occupancy Type for the 12 Critical Counties

General Occupancy Type Damage (12 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	183,790	358	0
Other Residential	57,508	2,490	0
Commercial	1,630	57	0
Industrial	293	13	0
Other	198	5	0
Total	243,419	2,923	0

Building damage is also described by building type, and in Alabama the most common building type is wood construction. Typically wood construction shows damage in proportion to the quantity of wood buildings, though due to the low level of shaking and relative flexibility of wood frame structures a very small proportion of Alabama wood frame buildings incur moderate or severe damage. Roughly 120 of the nearly 6,300 moderate and severe damage cases are wood frame. Mobile homes, which represent a much smaller portion of Alabama buildings, less than 20%, represent over 85% of the moderate and severe damage cases. This equates to 5,465 moderately or severely damaged mobile homes. Unreinforced masonry (URM) structures are also vulnerable to

the moderate levels of shaking Alabama's critical counties, in particular. Though URMs comprise only 5% of all Alabama buildings they account for roughly 550 moderately or severely damaged structures. Concrete, steel and reinforced masonry construction types represent considerably fewer cases of damage. Many cases of damage occur in the 12 critical counties, though other northern Alabama counties also experience instances of moderate damage.

Table 3: Building Damage by Building Type for State of Alabama

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,258,071	6,679	120	0	0
Steel	11,399	439	97	3	0
Concrete	3,156	100	23	0	0
Precast	857	28	10	1	0
Reinforced Masonry	5,178	70	24	1	0
Unreinforced Masonry	74,050	3,436	506	18	0
Mobile Home	278,809	31,026	5,417	48	0
Total	1,631,520	41,778	6,197	71	0

Even the most intense shaking in northwestern Alabama counties is not severe enough to generate many cases of damage to essential facilities. This damage state is identified by significant cracking to unreinforced masonry walls as well as some connection damage to column/beam joints in unreinforced masonry building. Liquefaction susceptibility data was not available when this scenario was completed and thus damage estimates may be slightly lower than if this liquefaction data were incorporated. Critical facilities remain largely unaffected by the New Madrid event with no cases of moderate or more severe damage and very limited loss of functionality the day after the earthquake, as shown in Table 4. These facilities will be equipped to treat injured persons and provide emergency services in the immediate aftermath of the earthquake.

Most transportation facilities remain undamaged for this NMSZ event. Highway bridges and roadways show no moderate or severe damage and no considerable loss of functionality immediately after the event. The same is true for railway facilities and rail lines as well as airports and their respective runways. Port facilities show that 38 facilities will not be operational immediately after the earthquake and are likely to remain as such for at least a week.

Table 4: Essential Facilities Damage & Functionality[1]

Essential Facilities Damage & Functionality					
Essential Facility Type	Total No. Facilities (State)	Total No. Facilities (12 Critical Counties)	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
Hospitals	137	19	0	0	137
Schools	1,870	270	0	0	1,870
EOCs	27	3	0	0	27
Police Stations	496	78	0	0	496
Fire Stations	1,388	250	0	0	1,388

Table 5: Damage to Highway Bridges

Highway Bridge Damage Assessments				
	Total No. of Bridges	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
12 Critical Counties	2,366	0	0	2,366
Remaining Counties	12,231	0	0	12,231
Total State	14,597	0	0	14,597

Table 6: Damage to Airports

Airport Damage Assessments				
	Total No. of Airports	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
12 Critical Counties	55	0	0	55
Remaining Counties	414	0	0	414
Total State	469	0	0	469

[1] For Tables 4-13 in this appendix the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Table 7: Transportation System Damage for the State of Alabama

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage> 50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	4,897	0	0	4,897
	Bridges	14,597	0	0	14,597
	Tunnels	0	0	0	0
Railways	Segments	2,678	0	0	2,678
	Bridges	118	0	0	118
	Tunnels	9	0	0	9
	Facilities	109	0	0	109
Bus	Facilities	24	0	0	24
Light Rail	Segments	0	0	0	0
	Bridges	0	0	0	0
	Facilities	0	0	0	0
Ferry	Facilities	6	6	6	0
Port	Facilities	321	0	0	274
Airport	Facilities	469	0	0	469
	Runways	292	0	0	292

As with transportation lifelines, utility lifelines remain largely unaffected by a NMSZ event. All utility facilities are operational the day after the earthquake and do not show any form of significant damage. While there is no appreciable damage to utility facilities, utility networks do experience some damage. Pipeline damage is estimated for local potable, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not part of the default inventory, or local inventory in HAZUS-MH MR2, though regional oil pipelines are added from HSIP 2007 to provide damage estimates for these major oil transmission lines. These oil pipelines are comprised of major crude oil and refined product lines only. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at roughly 180 and 722, respectively, as shown in Table 14. Local natural gas lines, however, show the greatest break and leak rates per length of pipe at roughly 0.01 leaks/mile (1 leak every 100 miles) and 0.003 breaks/mile (roughly 1 break every 333 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of 613 leaks and 153 breaks over the combined length of 59,263 miles of natural gas pipeline.

Table 8: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage > 50%)**	**Complete Damage (Damage > 50%)**	**Functionality >50% at Day 1**
12 Critical Counties	7	0	0	7
Remaining Counties	23	0	0	23
Total State	30	0	0	30

Table 9: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
12 Critical Counties	63	0	0	63
Remaining Counties	347	0	0	347
Total State	410	0	0	410

Table 10: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
12 Critical Counties	60	0	0	60
Remaining Counties	308	0	0	308
Total State	368	0	0	368

Table 11: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
12 Critical Counties	5	0	0	5
Remaining Counties	107	0	0	107
Total State	112	0	0	112

Table 12: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
12 Critical Counties	98	0	0	98
Remaining Counties	1,327	0	0	1,327
Total State	1,425	0	0	1,425

Table 13: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
12 Critical Counties	2,207	0	0	2,207
Remaining Counties	13,134	0	0	13,134
Total State	15,341	0	0	15,341

Potable water service is expected to be retained for all residences the day after the scenario earthquake. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program. Though the number of leaks and breaks may appear to be a large number, they are spread across many miles of pipeline, resulting in no interruptions in service as shown in Table 15. These damage estimates are very low compared to damage sustained by the same types of pipe in other states exposed to the NMSZ event. Without liquefaction information incorporated for the majority of the state it is difficult to calculate damage to underground pipelines. The permanent ground deformation calculated from liquefaction susceptibility is a critical factor in determining breaks and leaks to pipelines. For improved estimates of utility service outages, more liquefaction susceptibility information must be used.

Table 14: Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	200,893	722	180
Waste Water - Local	120,536	571	143
Natural Gas - Regional	8,558	3	1
Natural Gas - Local	50,705	610	152
Oil - Regional	2,913	1	0

Table 15: Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	1,737,080	0	0	0	0	0
Electric Power		0	0	0	0	0

A NOTE ON THE DETERMINATION OF DAMAGE TO INFRASTRUCTURE:

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

The following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county.

The damage estimates shown previously for the same infrastructure types are based on a different set of criteria as discussed in footnote (1) and employed in damage estimates for

the preceding tables. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Colbert County, Alabama – 10 waste water facilities
  - Estimation procedure according to footnote 1:
    - Summation of individual facilities after that facility is deemed 'damaged' or 'undamaged' based on 50% or greater damage likelihood requirement estimates **0 at least moderately damaged waste water facilities**
  - Estimation procedure according to topic damage tables in this appendix:
    - To determine the percentage of waste water facilities in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of facilities in that county
    - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **1 at least moderately damaged waste water facility**

In the case of Colbert County, Alabama, the topic damage tables in this appendix provide a higher estimate of damage as opposed to the facility-by-facility damage summation detailed in footnote (1). Though not illustrated here, it is possible to have a case where the point-by-point damage estimation procedure in footnote (1) predicts greater damage than the estimation procedure employed in the topic damage tables in this appendix. Comparing the total number of at least moderately damaged waste water facilities for the 12 critical counties in Alabama shows the following:

- Total number of at least moderately damaged waste water facilities according to the HAZUS-MH MR2 procedure for averaging damage at the county level
  - **3 at least moderately damaged waste water facilities**
- Total number of at least moderately damaged waste water facilities according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
  - **0 at least moderately damaged waste water facilities**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces greater damage. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this section of the appendix for the NMSZ scenario in Alabama.

The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Alabama. These tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage levels for a county.

Table 16: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Colbert						
Single Family	16,434	1,135	77	3	0	17,649
Other Residential	2,873	460	140	3	0	3,476
Commercial	129	30	12	1	0	172
Industrial	41	6	3	0	0	50
Other	17	4	2	0	0	23
Cullman						
Single Family	22,631	79	3	0	0	22,713
Other Residential	7,743	743	91	0	0	8,577
Commercial	214	6	1	0	0	221
Industrial	15	0	0	0	0	15
Other	24	1	0	0	0	25
Fayette						
Single Family	4,794	448	31	1	0	5,274
Other Residential	1,121	514	262	6	0	1,903
Commercial	18	7	3	0	0	28
Industrial	12	5	2	0	0	19
Other	2	1	0	0	0	3
Franklin						
Single Family	8,161	303	20	1	0	8,485
Other Residential	1,974	484	207	5	0	2,670
Commercial	50	6	2	0	0	58
Industrial	15	1	0	0	0	16
Other	3	0	0	0	0	3
Lamar						
Single Family	3,916	444	30	1	0	4,391
Other Residential	878	665	365	9	0	1,917
Commercial	12	5	2	0	0	19
Industrial	8	3	2	0	0	13
Other	3	1	0	0	0	4
Lauderdale						
Single Family	26,861	1,814	123	4	0	28,802
Other Residential	3,799	1,009	427	10	0	5,245
Commercial	206	60	24	2	0	292
Industrial	22	6	3	0	0	31
Other	26	4	1	0	0	31
Lawrence						
Single Family	9,354	33	1	0	0	9,388
Other Residential	3,938	387	48	0	0	4,373
Commercial	32	1	0	0	0	33
Industrial	4	0	0	0	0	4
Other	6	0	0	0	0	6

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Limestone						
Single Family	19,418	68	3	0	0	19,489
Other Residential	4,219	391	48	0	0	4,658
Commercial	103	3	0	0	0	106
Industrial	2	0	0	0	0	2
Other	23	1	0	0	0	24
Marion						
Single Family	7,618	411	28	1	0	8,058
Other Residential	2,735	795	357	8	0	3,895
Commercial	40	8	3	0	0	51
Industrial	13	3	1	0	0	17
Other	7	1	1	0	0	9
Morgan						
Single Family	33,621	117	5	0	0	33,743
Other Residential	6,412	552	67	0	0	7,031
Commercial	356	10	1	0	0	367
Industrial	75	2	0	0	0	77
Other	41	1	0	0	0	42
Walker						
Single Family	18,950	66	3	0	0	19,019
Other Residential	8,565	832	102	0	0	9,499
Commercial	226	6	1	0	0	233
Industrial	8	0	0	0	0	8
Other	20	0	0	0	0	20
Winston						
Single Family	6,430	325	22	1	0	6,778
Other Residential	3,146	782	327	7	0	4,262
Commercial	38	9	4	0	0	51
Industrial	34	4	1	0	0	39
Other	6	0	0	0	0	6

Table 17: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Colbert	313	212	67.70	213	68.20	282	90.10	312	99.70	312	99.80
Cullman	215	196	91.10	196	91.30	212	98.40	215	99.90	215	99.90
Fayette	183	124	67.70	125	68.20	165	90.10	182	99.70	183	99.80
Franklin	133	106	79.40	106	79.75	125	94.25	133	99.80	133	99.85
Lamar	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lauderdale	372	251.84	67.7	253.7	68.2	335.17	90.1	370.88	99.7	371.26	99.8
Lawrence	98	89.278	91.1	89.474	91.3	96.432	98.4	97.902	99.9	97.902	99.9
Limestone	101	92.011	91.1	92.213	91.3	99.384	98.4	100.9	99.9	100.9	99.9
Marion	128	102	79.40	102	79.75	121	94.25	128	99.80	128	99.85
Morgan	715	651	91.10	653	91.30	704	98.40	714	99.90	714	99.90
Walker	267	243	91.10	244	91.30	263	98.40	267	99.90	267	99.90
Winston	99	67	67.70	68	68.20	89	90.10	99	99.70	99	99.80

* Note: Discrepancies between the number of hospital beds and the percentage of beds may occur due to rounding.

Table 18: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Colbert	9	61.28
Cullman	5	94.10
Fayette	3	65.97
Franklin	5	77.22
Lamar	5	51.90
Lauderdale	9	75.34
Lawrence	6	94.10
Limestone	5	94.10
Marion	8	73.00
Morgan	9	94.10
Walker	9	94.10
Winston	5	85.66

Table 19: School Functionality

Counties	Count	Functionality at Day 1 (%)
Colbert	26	70.47
Cullman	37	94.10
Fayette	7	65.97
Franklin	13	80.03
Lamar	7	51.90
Lauderdale	28	64.88
Lawrence	16	94.10
Limestone	26	94.10
Marion	18	76.72
Morgan	46	94.10
Walker	33	94.10
Winston	13	77.87

Table 20: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Colbert	20	75.11
Cullman	53	94.10
Fayette	13	61.64
Franklin	14	73.00
Lamar	10	51.90
Lauderdale	23	70.25
Lawrence	11	94.10
Limestone	20	94.10
Marion	12	73.00
Morgan	34	94.10
Walker	26	94.10
Winston	14	79.03

Table 21: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Colbert	315	94.44	99.10	99.50	99.90	99.90
Cullman	272	99.50	99.90	99.90	99.90	99.90
Fayette	52	98.89	99.80	99.85	99.90	99.90
Franklin	107	97.67	99.61	99.76	99.90	99.90
Lamar	50	94.33	99.08	99.49	99.90	99.90
Lauderdale	217	95.23	99.22	99.56	99.90	99.90
Lawrence	107	99.50	99.90	99.90	99.90	99.90
Limestone	184	99.50	99.90	99.90	99.90	99.90
Marion	131	95.27	99.23	99.56	99.90	99.90
Morgan	442	99.50	99.90	99.90	99.90	99.90
Walker	245	99.50	99.90	99.90	99.90	99.90
Winston	85	99.50	99.90	99.90	99.90	99.90

Table 22: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Colbert	22,461	0.00	0.00	0.00	0.00	0.00
Cullman	30,706	0.00	0.00	0.00	0.00	0.00
Fayette	7,493	0.00	0.00	0.00	0.00	0.00
Franklin	12,259	0.00	0.00	0.00	0.00	0.00
Lamar	6,468	0.00	0.00	0.00	0.00	0.00
Lauderdale	36,088	0.00	0.00	0.00	0.00	0.00
Lawrence	13,538	0.00	0.00	0.00	0.00	0.00
Limestone	24,688	0.00	0.00	0.00	0.00	0.00
Marion	12,697	0.00	0.00	0.00	0.00	0.00
Morgan	43,602	0.00	0.00	0.00	0.00	0.00
Walker	28,364	0.00	0.00	0.00	0.00	0.00
Winston	10,107	0.00	0.00	0.00	0.00	0.00

Table 23: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Colbert	2	50.0%	37.6%	11.4%	1.0%	0.1%
Cullman	1	89.8%	9.4%	0.7%	0.0%	0.0%
Fayette	2	89.8%	9.4%	0.7%	0.0%	0.0%
Franklin	0	N/A	N/A	N/A	N/A	N/A
Lamar	0	N/A	N/A	N/A	N/A	N/A
Lauderdale	0	N/A	N/A	N/A	N/A	N/A
Lawrence	1	89.8%	9.4%	0.7%	0.0%	0.0%
Limestone	1	89.8%	9.4%	0.7%	0.0%	0.0%
Marion	0	N/A	N/A	N/A	N/A	N/A
Morgan	0	N/A	N/A	N/A	N/A	N/A
Walker	0	N/A	N/A	N/A	N/A	N/A
Winston	0	N/A	N/A	N/A	N/A	N/A

Table 24: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Colbert	1,510	8	2
Cullman	2,412	13	3
Fayette	1,359	7	2
Franklin	1,491	16	4
Lamar	1,412	22	5
Lauderdale	2,088	11	3
Lawrence	1,454	8	2
Limestone	1,591	9	2
Marion	1,857	28	7
Morgan	1,752	10	2
Walker	2,235	12	3
Winston	1,468	8	2

Table 25: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Colbert	22,461	0.00	0.00	0.00	0.00	0.00
Cullman	30,706	0.00	0.00	0.00	0.00	0.00
Fayette	7,493	0.00	0.00	0.00	0.00	0.00
Franklin	12,259	0.00	0.00	0.00	0.00	0.00
Lamar	6,468	0.00	0.00	0.00	0.00	0.00
Lauderdale	36,088	0.00	0.00	0.00	0.00	0.00
Lawrence	13,538	0.00	0.00	0.00	0.00	0.00
Limestone	24,688	0.00	0.00	0.00	0.00	0.00
Marion	12,697	0.00	0.00	0.00	0.00	0.00
Morgan	43,602	0.00	0.00	0.00	0.00	0.00
Walker	28,364	0.00	0.00	0.00	0.00	0.00
Winston	10,107	0.00	0.00	0.00	0.00	0.00

Table 26: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Colbert	10	54.0%	34.8%	10.3%	0.9%	0.1%
Cullman	9	89.8%	9.4%	0.7%	0.0%	0.0%
Fayette	2	89.8%	9.4%	0.7%	0.0%	0.0%
Franklin	5	65.9%	26.3%	7.1%	0.6%	0.0%
Lamar	5	65.9%	26.3%	7.1%	0.6%	0.0%
Lauderdale	2	50.0%	37.6%	11.4%	1.0%	0.1%
Lawrence	4	89.8%	9.4%	0.7%	0.0%	0.0%
Limestone	5	89.8%	9.4%	0.7%	0.0%	0.0%
Marion	5	65.9%	26.3%	7.1%	0.6%	0.0%
Morgan	8	89.8%	9.4%	0.7%	0.0%	0.0%
Walker	7	89.8%	9.4%	0.7%	0.0%	0.0%
Winston	1	89.8%	9.4%	0.7%	0.0%	0.0%

Table 27: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Colbert	906	7	2
Cullman	1,447	10	3
Fayette	816	6	1
Franklin	895	13	3
Lamar	847	17	4
Lauderdale	1,253	9	2
Lawrence	872	6	2
Limestone	955	7	2
Marion	1,114	22	5
Morgan	1,051	8	2
Walker	1,341	10	2
Winston	881	6	2

Table 28: Highway Bridge Damage

Counties	# of Bridges	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Colbert	131	97.19%	1.93%	0.54%	0.28%	0.04%
Cullman	230	98.28%	1.15%	0.35%	0.18%	0.02%
Fayette	162	97.66%	1.72%	0.38%	0.19%	0.02%
Franklin	182	97.18%	2.00%	0.51%	0.26%	0.03%
Lamar	172	98.68%	0.99%	0.19%	0.11%	0.01%
Lauderdale	227	96.76%	2.28%	0.60%	0.30%	0.04%
Lawrence	211	98.33%	1.08%	0.36%	0.19%	0.03%
Limestone	299	97.10%	1.96%	0.59%	0.30%	0.04%
Marion	232	98.12%	1.32%	0.34%	0.18%	0.02%
Morgan	239	97.81%	1.37%	0.50%	0.27%	0.04%
Walker	196	96.28%	2.50%	0.77%	0.38%	0.05%
Winston	85	97.74%	1.62%	0.40%	0.20%	0.03%

Table 29: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Colbert	131	98.75	99.39	99.61	99.64	99.78
Cullman	230	99.20	99.58	99.72	99.74	99.82
Fayette	162	99.02	99.55	99.70	99.72	99.81
Franklin	182	98.78	99.42	99.63	99.66	99.78
Lamar	172	99.43	99.72	99.80	99.81	99.86
Lauderdale	227	98.60	99.34	99.58	99.62	99.76
Lawrence	211	99.19	99.56	99.70	99.73	99.82
Limestone	299	98.69	99.35	99.59	99.63	99.76
Marion	232	99.17	99.58	99.72	99.74	99.82
Morgan	239	98.94	99.42	99.62	99.65	99.78
Walker	196	98.33	99.19	99.49	99.54	99.72
Winston	85	99.02	99.53	99.69	99.72	99.81

Alabama – East Tennessee Seismic Zone Scenario

This earthquake impact assessment includes all 67 counties in the State of Alabama. For the purposes of this analysis, 13 critical counties have been identified in the northeastern portion of the state where shaking is anticipated to be most intense. These 13 counties are the focus of much of the damage assessment included within this document, though it is possible for damage to occur outside these 13 counties. The critical counties are listed below:

- Blount
- Calhoun
- Cherokee
- Dekalb
- Etowah
- Jackson
- Jefferson
- Limestone
- Madison
- Marshall
- Morgan
- Saint Clair
- Talladega

Please note, the critical counties chosen for the East Tennessee Seismic Zone (ETSZ) scenario are different then those used in the New Madrid Seismic Zone (NMSZ) scenario. Counties closest to the seismic source are considered critical, thus the ETSZ critical counties are located in the northeastern portion of Alabama, while NMSZ critical counties are located in the northwestern portion of Alabama. For names and locations of critical counties in each scenario event please reference the main section of this report and the damage and functionality maps in another appendix.

The earthquake impact assessment for the State of Alabama employs one scenario event in Dekalb County. The scenario consists of a M_w5.9 earthquake in the East Tennessee Seismic Zone (ETSZ). The epicenter location as well as all soil and liquefaction data were provided by the Geologic Survey of Alabama (GSA) and shown in Figure 2. A set of five attenuation functions was used to generate ground motion. The attenuations and weighting factors are listed below:

Atkinson and Boore (1997)	0.250
Toro, Abrahamson and Schneider (1997)	0.250
Frankel, Mueller, Barnhard, Perkins et al. (1996)	0.250
Campbell (2002)	0.125
Sommerville, Collins, Abrahamson et al. (2002)	0.125

It is relevant to note that the attenuation from Frankel, Mueller, Barnhard, Perkins et al. (1996) can not be computed for a magnitude of 5.9. The attenuation only applies to earthquakes with magnitudes of 6.0 or greater. In order to determine regional ground shaking with this attenuation a magnitude of 6.0 was used. The four remaining attenuations employed a magnitude 5.9, as prescribed by GSA. This change does not impact the intensity of regional shaking significantly and is acceptable for the purposes of this assessment.

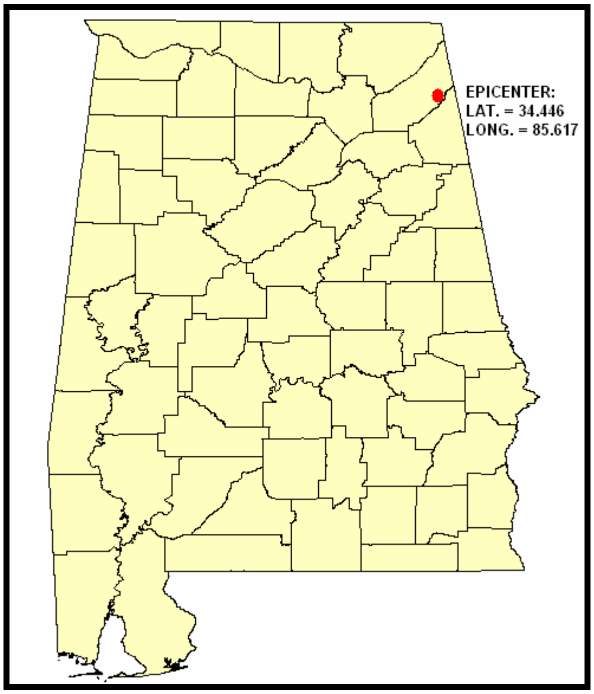

Figure 2: Location of M_w5.9 Earthquake

The East Tennessee Seismic Zone scenario generates nearly 550 cases of complete damage, unlike the New Madrid Seismic Zone scenario. All of these cases of complete damage occur nearest the epicenter in DeKalb, Etowah and Jackson Counties. Table 30 and Table 31 report at least moderate damage which includes moderate to severe damage and complete damage. All of the damage estimates for the at least moderate damage case include complete damage. Since there are no cases of complete damage in the NMSZ scenario for Alabama the moderate to severe damage level can be considered at least moderate and compared to the building damage shown here for the ETSZ scenario.

Table 30: Damage by General Occupancy Type for the State of Alabama

General Occupancy Type Damage (State level)			
General Occupancy Type	**Total No. Buildings**	**At Least Moderate Damage**	**Complete Damage**
Single Family	1,303,224	2,431	410
Other Residential	354,031	3,241	127
Commercial	18,249	61	5
Industrial	2,048	48	2
Other	2,014	5	0
Total	1,679,566	5,786	544

The ETSZ scenario generates nearly 5,800 cases of at least moderate damage across the entire state. This is approximately 500 fewer cases than the NMSZ scenario. Nearly all damaged structures are located in the 13 critical counties, though less than half of the structural damage in the NMSZ scenario is confined to the critical counties. As with the previous scenario for Alabama, nearly all damage, roughly 98%, is incurred by

residential structures. The remaining 2% is attributed to commercial, industrial and other buildings which include government, educational, religious and agricultural buildings.

Wood construction accounts for 45% of all building damage in this earthquake scenario. Additionally, mobile homes (MH) consist of 47 % of the damages cases, while unreinforced masonry (URM) account for 8% of all building damage. Concrete, steel and reinforced masonry construction types represent considerably fewer cases of damage.

Table 31: Damage by General Occupancy Type for the 13 Critical Counties

General Occupancy Type Damage (13 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**At Least Moderate Damage**	**Complete Damage**
Single Family	535,829	2,427	410
Other Residential	106,769	3,216	127
Commercial	10,454	60	5
Industrial	815	48	2
Other	777	5	0
Total	654,644	5,756	544

Table 32: Building Damage by Building Type for State of Alabama

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,255,446	7,365	1,596	69	394
Steel	11,814	64	42	14	4
Concrete	3,247	16	11	4	2
Precast	879	8	5	2	0
Reinforced Masonry	5,234	19	14	5	3
Unreinforced Masonry	76,394	1,127	371	81	38
Mobile Home	305,185	6,983	2,675	352	105
Total	1,658,199	15,582	4,714	527	546

Numerous essential facilities experience moderate or significant damage from the scenario earthquake. There are 12 fire stations in northeastern Alabama that incur at least moderate damage and 22 facilities are not operational the day after the event. Several police stations and schools are damaged and not functional immediately after the event which is likely to inhibit the emergency response in these heavily damaged areas of northeastern Alabama. Table 33 illustrates essential facilities damage throughout the state, while Table 34 shows damage for the 13 critical counties only.

Table 33: Essential Facilities Damage & Functionality for the State of Alabama[2]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	137	1	0	136
Schools	1,870	8	0	1,856
EOCs	27	0	0	27
Police Stations	496	6	0	485
Fire Stations	1,388	12	0	1,366

Table 34: Essential Facilities Damage & Functionality for 13 Critical Counties

Essential Facilities Damage & Functionality (13 Critical Counties)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	48	1	0	47
Schools	698	8	0	690
EOCs	8	0	0	7
Police Stations	161	6	0	150
Fire Stations	419	12	0	397

Damage to transportation facilities and networks is very limited even though the ETSZ scenario produces more intense shaking in portions of northeastern Alabama. Only one highway bridge incurs moderate damage and only one bridge is not operational the day after the earthquake. All airports are undamaged and remain operational immediately after the earthquake, as do all railway and bus facilities. Numerous ports show reduced functionality the day after the earthquake as 47 ports are not operational. The same inventory used in the Alabama NMSZ scenario was employed in this scenario and thus the same updates from HSIP 2007 apply.

Table 35: Damage to Highway Bridges

Highway Bridge Damage Assessments				
	Total No. of Bridges	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality > 50% at Day 1**
13 Critical Counties	4,014	1	0	4,013
Remaining Counties	10,583	0	0	10,583
Total State	14,597	1	0	14,596

[2] For Tables 33-43 in this appendix the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Table 36: Damage to Airports

Airport Damage Assessments				
	Total No. of Airports	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality > 50% at Day 1
13 Critical Counties	115	0	0	115
Remaining Counties	354	0	0	354
Total State	469	0	0	469

Table 37: Transportation System Damage for State of Alabama

Transportation System Damage					
Transportation System	Type	Quantity	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality at Day 1 < 50%
Highway	Segments	4,897	0	0	4,897
	Bridges	14,597	1	0	14,596
	Tunnels	0	0	0	0
Railways	Segments	2,678	0	0	2,678
	Bridges	118	0	0	118
	Tunnels	9	0	0	9
	Facilities	109	0	0	109
Bus	Facilities	24	0	0	24
Light Rail	Segments	0	0	0	0
	Bridges	0	0	0	0
	Facilities	0	0	0	0
Ferry	Facilities	6	6	6	0
Port	Facilities	321	0	0	274
Airport	Facilities	469	0	0	469
	Runways	292	0	0	292

Utility lifelines show more substantial damage to networks than their facility counterparts. Very few facilities are moderately damaged. Potable water, waste water and electric power facilities incur a total of four moderately damaged facilities nearest the epicenter. Communication facilities incur numerous cases of damage in northeastern Alabama. Over 162 facilities are moderately damaged though this only equates to 3% of all facilities in the critical counties and roughly 1% of all communication facilities in the State of Alabama. The functionality of utility facilities in Alabama is largely unchanged by the earthquake in the ETSZ. Several facilities nearest the epicenter are not operational the day after the earthquake, though the majority of the state retains its services.

Table 38: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality > 50% at Day 1
13 Critical Counties	14	1	0	13
Remaining Counties	16	0	0	16
Total State	30	1	0	29

Table 39: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage > 50%)	Functionality > 50% at Day 1
13 Critical Counties	130	2	0	125
Remaining Counties	280	0	0	280
Total State	410	2	0	405

Table 40: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
13 Critical Counties	100	0	0	100
Remaining Counties	268	0	0	268
Total State	368	0	0	368

Table 41: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
13 Critical Counties	38	0	0	38
Remaining Counties	74	0	0	74
Total State	112	0	0	112

Table 42: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality > 50% at Day 1
13 Critical Counties	395	1	0	394
Remaining Counties	1,030	0	0	1,030
Total State	1,425	1	0	1,424

Table 43: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality > 50% at Day 1
13 Critical Counties	5,180	162	0	5,149
Remaining Counties	10,161	0	0	10,161
Total State	15,341	162	0	15,310

Pipelines incur several hundred leaks and breaks throughout the state. Potable water lines show the greatest amount of both breaks and leaks at roughly 71 and 188, respectively. In addition, waste water lines show an estimated 149 leaks and 56 breaks, over nearly 75,000 miles of pipe. Regional natural gas and oil pipelines show no breaks and leaks. The lack of damage to regional pipelines is likely due to the low levels of shaking throughout the majority of the state. In addition, regions with more intense shaking near the epicenter are also comprised of very stable soils that are unlikely to liquefy. Without substantial ground deformation pipelines are unlikely to break. With very little damage to potable water lines the number of households without water, even immediately after the event, is very low. Electric power, however, is out for nearly 7,400 households in northeastern Alabama. Numerous households have service restored within a week, though roughly 1,700 households are still without power. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program.

Table 44: Pipeline Damage

Pipeline Damage			
System	Total Pipelines (mi)	No. Leaks	No. Breaks
Potable Water - Local	124,755	188	71
Waste Water - Local	74,853	149	56
Natural Gas - Regional	5,306	0	0
Natural Gas - Local	4,990	159	60
Oil - Regional	1,809	0	0

Table 45: Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Electric Power	1,737,080	7,389	4,367	1,715	349	10
Potable Water		0	0	0	0	0

A NOTE ON THE DETERMINATION OF DAMAGE TO INFRASTRUCTURE:

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify

damage based on the likelihood of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

The following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed in HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county.

The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as discussed in footnote (2) and employed in the preceding damage tables for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Dekalb County, Alabama – 7 waste water facilities
    - Estimation procedure according to footnote 2:
        - Summation of individual facilities after that facility is deemed 'damaged' or 'undamaged' based on 50% or greater damage likelihood requirement estimates 1 **at least moderately damaged waste water facility**
    - Estimation procedure according to topic damage tables in this appendix:
        - To determine the percentage of waste water facilities in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of facilities in that county
        - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **2 at least moderately damaged waste water facilities**

In the case of Dekalb County, Alabama, the topic damage tables in this appendix provide a higher estimate of damage as opposed to the facility-by-facility damage summation detailed in footnote (2). Though not illustrated here, other counties in Alabama are estimated to incur greater damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged waste water facilities for the 13 critical counties in Alabama shows the following:

- Total number of at least moderately damaged waste water facilities according to the HAZUS-MH MR2 procedure for averaging damage at the county level
    - **5 at least moderately damaged waste water facilities**
- Total number of at least moderately damaged waste water facilities according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
    - **2 at least moderately damaged waste water facilities**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces greater damage. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix for the ETSZ scenario in Alabama.

The following tables provide damage and functionality estimates for the ETSZ scenario critical counties in Alabama. These tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage levels for a county.

Table 46: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Blount						
Single Family	13,876	25	1	0	0	13,902
Other Residential	5,988	126	7	0	0	6,121
Commercial	4,401	41	3	0	0	4,445
Industrial	10	0	0	0	0	10
Other	31	0	0	0	0	31
Calhoun						
Single Family	33,821	112	4	0	0	33,937
Other Residential	9,256	352	26	0	0	9,634
Commercial	345	4	0	0	0	349
Industrial	71	1	0	0	0	72
Other	37	0	0	0	0	37
Cherokee						
Single Family	5,611	1,417	242	10	0	7,280
Other Residential	2,422	1,311	912	69	0	4,714
Commercial	32	5	2	0	0	39
Industrial	2	0	0	0	0	2
Other	10	2	1	0	0	13
Dekalb						
Single Family	10,799	4,909	1,562	123	10	17,403
Other Residential	3,405	2,074	1,440	299	37	7,255
Commercial	58	40	36	9	1	144
Industrial	20	19	31	15	2	87
Other	10	5	3	1	0	19
Etowah						
Single Family	31,942	403	18	0	262	32,625
Other Residential	6,136	513	60	0	33	6,742
Commercial	290	10	1	0	2	303
Industrial	22	0	0	0	0	22
Other	31	1	0	0	0	32
Jackson						
Single Family	14,666	664	35	1	138	15,504
Other Residential	5,067	959	187	1	57	6,271
Commercial	96	8	2	0	2	108
Industrial	9	1	0	0	0	10
Other	14	1	0	0	0	15
Jefferson						
Single Family	206,275	86	3	0	0	206,364
Other Residential	17,315	82	3	0	0	17,400
Commercial	2,940	6	0	0	0	2,946
Industrial	216	0	0	0	0	216
Other	310	1	0	0	0	311

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Limestone						
Single Family	19,471	17	1	0	0	19,489
Other Residential	4,611	45	2	0	0	4,658
Commercial	106	0	0	0	0	106
Industrial	2	0	0	0	0	2
Other	24	0	0	0	0	24
Madison						
Single Family	93,692	193	7	0	0	93,892
Other Residential	10,713	206	13	0	0	10,932
Commercial	1,112	9	1	0	0	1,122
Industrial	204	1	0	0	0	205
Other	185	1	0	0	0	186
Marshall						
Single Family	24,265	193	7	0	0	24,465
Other Residential	6,561	456	46	0	0	7,063
Commercial	230	7	1	0	0	238
Industrial	54	1	0	0	0	55
Other	21	1	0	0	0	22
Morgan						
Single Family	33,701	40	1	0	0	33,742
Other Residential	6,918	107	6	0	0	7,031
Commercial	365	2	0	0	0	367
Industrial	78	0	0	0	0	78
Other	42	0	0	0	0	42
Saint Clair						
Single Family	16,709	42	1	0	0	16,752
Other Residential	9,044	214	13	0	0	9,271
Commercial	112	1	0	0	0	113
Industrial	38	0	0	0	0	38
Other	28	0	0	0	0	28
Talladega						
Single Family	20,454	19	1	0	0	20,474
Other Residential	9,559	113	5	0	0	9,677
Commercial	173	1	0	0	0	174
Industrial	18	0	0	0	0	18
Other	17	0	0	0	0	17

*Note: The summation of the individual buildings damage at different damage levels may not sum to the total amount of buildings damaged; this is due to rounding discrepancies.

Table 47: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Blount	40	40	100.00	40	100.00	40	100.00	40	100.00	40	100.00
Calhoun	745	744	99.87	744	99.87	744	99.87	744	99.87	744	99.87
Cherokee	60	52	86.67	52	86.67	58	96.67	60	100.00	60	100.00
Dekalb	134	22	16.42	23	17.16	59	44.03	121	90.30	127	94.78
Etowah	735	689	93.74	690	93.88	707	96.19	710	96.60	713	97.01
Jackson	170	164	96.47	165	97.06	169	99.41	170	100.00	170	100.00
Jefferson	5,788	5,787	99.98	5,787	99.98	5,787	99.98	5,787	99.98	5,787	99.98
Limestone	101	101	100.00	101	100.00	101	100.00	101	100.00	101	100.00
Madison	991	990	99.90	990	99.90	990	99.90	990	99.90	990	99.90
Marshall	240	237	98.75	237	98.75	240	100.00	240	100.00	240	100.00
Morgan	715	714	99.86	714	99.86	714	99.86	714	99.86	714	99.86
Saint Clair	82	82	100.00	82	100.00	82	100.00	82	100.00	82	100.00
Talladega	298	298	100.00	298	100.00	298	100.00	298	100.00	298	100.00

* Note: Discrepancies between the number of hospital beds and the percentage of beds may occur due to rounding.

Table 48: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Blount	161	99.86	99.90	99.90	99.90	99.90
Calhoun	357	99.68	99.90	99.90	99.90	99.90
Cherokee	85	87.88	96.69	97.81	99.56	99.85
Dekalb	266	69.04	85.51	89.44	97.40	99.49
Etowah	293	98.54	99.78	99.86	99.90	99.90
Jackson	229	96.44	99.44	99.69	99.90	99.90
Jefferson	1,681	99.90	99.90	99.90	99.90	99.90
Limestone	184	99.90	99.90	99.90	99.90	99.90
Madison	649	99.82	99.90	99.90	99.90	99.90
Marshall	255	99.12	99.87	99.90	99.90	99.90
Morgan	442	99.89	99.90	99.90	99.90	99.90
Saint Clair	310	99.86	99.90	99.90	99.90	99.90
Talladega	268	99.90	99.90	99.90	99.90	99.90

Table 49: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Blount	7	96.43
Calhoun	10	94.79
Cherokee	4	41.90
Dekalb	14	34.67
Etowah	12	91.47
Jackson	10	79.31
Jefferson	46	98.89
Limestone	5	98.14
Madison	16	96.30
Marshall	9	91.06
Morgan	9	97.52
Saint Clair	12	96.89
Talladega	7	98.20

Table 50: School Functionality

Counties	Count	Functionality at Day 1 (%)
Blount	18	96.92
Calhoun	45	95.11
Cherokee	8	45.43
Dekalb	18	33.26
Etowah	46	87.60
Jackson	30	79.06
Jefferson	253	98.95
Limestone	26	98.14
Madison	107	96.49
Marshall	36	91.83
Morgan	46	97.61
Saint Clair	29	96.76
Talladega	36	98.05

Table 51: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Blount	22	96.91
Calhoun	23	94.54
Cherokee	13	53.02
Dekalb	29	35.97
Etowah	32	86.42
Jackson	27	80.11
Jefferson	106	98.94
Limestone	20	98.26
Madison	46	96.34
Marshall	23	91.51
Morgan	34	97.48
Saint Clair	23	96.56
Talladega	21	98.23

Table 52: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Blount	19,265	0	0.00	0	0.00	0
Calhoun	45,307	0	0.00	0	0.00	0
Cherokee	9,719	0	0.00	0	0.00	0
Dekalb	25,113	0	0.00	0	0.00	0
Etowah	41,615	0	0.00	0	0.00	0
Jackson	21,615	0	0.00	0	0.00	0
Jefferson	263,265	0	0.00	0	0.00	0
Limestone	24,688	0	0.00	0	0.00	0
Madison	109,955	0	0.00	0	0.00	0
Marshall	32,547	0	0.00	0	0.00	0
Morgan	43,602	0	0.00	0	0.00	0
Saint Clair	24,143	0	0.00	0	0.00	0
Talladega	30,674	0	0.00	0	0.00	0

Table 53: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Blount	3	95.8%	4.0%	0.2%	0.0%	0.0%
Calhoun	0	0.0%	0.0%	0.0%	0.0%	0.0%
Cherokee	0	0.0%	0.0%	0.0%	0.0%	0.0%
Dekalb	1	4.9%	25.8%	43.5%	21.6%	4.2%
Etowah	2	82.2%	15.9%	1.8%	0.1%	0.0%
Jackson	2	70.3%	24.6%	4.8%	0.3%	0.0%
Jefferson	3	99.7%	0.3%	0.0%	0.0%	0.0%
Limestone	1	99.4%	0.6%	0.0%	0.0%	0.0%
Madison	0	0.0%	0.0%	0.0%	0.0%	0.0%
Marshall	2	86.2%	12.6%	1.2%	0.0%	0.0%
Morgan	0	0.0%	0.0%	0.0%	0.0%	0.0%
Saint Clair	0	0.0%	0.0%	0.0%	0.0%	0.0%
Talladega	0	0.0%	0.0%	0.0%	0.0%	0.0%

Table 54: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Blount	3	96.1%	3.7%	0.2%	0.0%	0.0%
Calhoun	6	90.9%	8.3%	0.7%	0.0%	0.0%
Cherokee	3	27.5%	40.1%	25.6%	5.9%	0.8%
Dekalb	7	29.7%	38.8%	25.1%	5.7%	0.7%
Etowah	9	79.7%	17.4%	2.8%	0.1%	0.0%
Jackson	12	68.9%	24.7%	5.9%	0.5%	0.0%
Jefferson	20	99.5%	0.5%	0.0%	0.0%	0.0%
Limestone	5	98.6%	1.4%	0.0%	0.0%	0.0%
Madison	16	96.1%	3.7%	0.2%	0.0%	0.0%
Marshall	16	87.4%	11.4%	1.1%	0.0%	0.0%
Morgan	8	97.6%	2.3%	0.1%	0.0%	0.0%
Saint Clair	8	96.4%	3.4%	0.2%	0.0%	0.0%
Talladega	17	98.7%	1.3%	0.0%	0.0%	0.0%

Table 55: Highway Bridge Damage

Counties	# of Bridges	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Blount	178	99.91%	0.08%	0.00%	0.00%	0.00%
Calhoun	288	99.56%	0.42%	0.01%	0.00%	0.00%
Cherokee	159	90.66%	6.78%	0.91%	0.82%	0.82%
Dekalb	287	89.23%	8.04%	1.23%	1.07%	0.41%
Etowah	209	98.34%	1.48%	0.04%	0.09%	0.03%
Jackson	270	96.41%	3.32%	0.14%	0.12%	0.01%
Jefferson	958	99.99%	0.01%	0.00%	0.00%	0.00%
Limestone	299	99.96%	0.03%	0.00%	0.00%	0.00%
Madison	567	99.84%	0.15%	0.00%	0.00%	0.00%
Marshall	165	99.32%	0.65%	0.01%	0.00%	0.00%
Morgan	239	99.95%	0.05%	0.00%	0.00%	0.00%
Saint Clair	163	99.88%	0.11%	0.00%	0.00%	0.00%
Talladega	232	99.96%	0.03%	0.00%	0.00%	0.00%

Table 56: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Blount	178	99.96	99.98	99.98	99.98	99.98
Calhoun	288	99.86	99.97	99.97	99.97	99.97
Cherokee	159	95.97	97.95	98.29	98.41	98.88
Dekalb	287	95.59	97.97	98.44	98.60	99.17
Etowah	209	99.42	99.80	99.82	99.83	99.88
Jackson	270	98.88	99.75	99.80	99.82	99.88
Jefferson	958	99.97	99.97	99.97	99.97	99.97
Limestone	299	99.97	99.97	99.97	99.97	99.97
Madison	567	99.94	99.97	99.97	99.97	99.97
Marshall	165	99.78	99.95	99.95	99.95	99.95
Morgan	239	99.97	99.98	99.98	99.98	99.98
Saint Clair	163	99.95	99.97	99.97	99.97	99.97
Talladega	232	99.98	99.98	99.98	99.98	99.98

Table 57: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Blount	1,905	2	0
Calhoun	2,344	3	1
Cherokee	1,517	32	8
Dekalb	2,588	98	24
Etowah	2,052	7	8
Jackson	2,151	14	21
Jefferson	5,801	2	1
Limestone	1,591	1	0
Madison	2,876	3	1
Marshall	1,964	4	1
Morgan	1,752	1	0
Saint Clair	1,961	2	0
Talladega	2,399	1	0

Table 58: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Blount	19,265	0.00	0.00	0.00	0.00	0.00
Calhoun	45,307	0.00	0.00	0.00	0.00	0.00
Cherokee	9,719	19.31	9.41	2.41	0.29	0.03
Dekalb	25,113	21.95	13.75	5.90	1.28	0.03
Etowah	41,615	0.00	0.00	0.00	0.00	0.00
Jackson	21,615	0.00	0.00	0.00	0.00	0.00
Jefferson	263,265	0.00	0.00	0.00	0.00	0.00
Limestone	24,688	0.00	0.00	0.00	0.00	0.00
Madison	109,955	0.00	0.00	0.00	0.00	0.00
Marshall	32,547	0.00	0.00	0.00	0.00	0.00
Morgan	43,602	0.00	0.00	0.00	0.00	0.00
Saint Clair	24,143	0.00	0.00	0.00	0.00	0.00
Talladega	30,674	0.00	0.00	0.00	0.00	0.00

Table 59: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Blount	1,143	1	0
Calhoun	1,407	2	1
Cherokee	910	25	6
Dekalb	1,553	77	19
Etowah	1,231	5	6
Jackson	1,290	11	17
Jefferson	3,480	2	0
Limestone	954	1	0
Madison	1,726	2	1
Marshall	1,179	3	1
Morgan	1,051	1	0
Saint Clair	1,177	1	0
Talladega	1,439	1	0

Arkansas – New Madrid Seismic Zone Scenario

This earthquake impact assessment includes all 75 counties in the State of Arkansas. Arkansas is approximately 53,200 square miles and is bordered by Missouri to the north, Louisiana to the south, Tennessee and Mississippi to the east and Oklahoma to the west. For the purposes of this analysis, 34 critical counties have been identified in the northeastern portion of the state where shaking is anticipated to be most intense. These 34 counties are the focus of much of the damage assessment included within this document. The critical counties are listed below:

- Arkansas
- Baxter
- Clay
- Cleburne
- Cleveland
- Craighead
- Crittenden
- Cross
- Desha
- Faulkner
- Fulton
- Grant
- Greene
- Independence
- Izard
- Jackson
- Jefferson
- Lawrence
- Lee
- Lincoln
- Lonoke
- Mississippi
- Monroe
- Phillips
- Poinsett
- Prairie
- Pulaski
- Randolph
- St. Francis
- Sharp
- Stone
- Van Buren
- White
- Woodruff

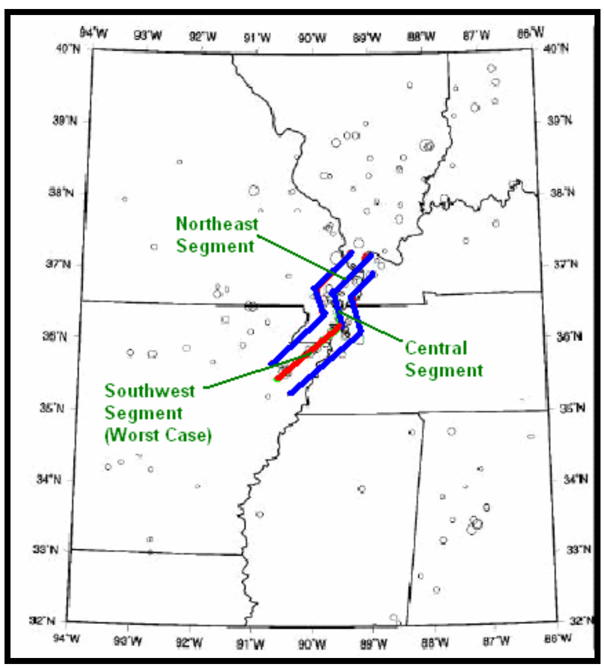

Figure 3: Scenario Fault Location for the State of Arkansas

The earthquake impact assessment for the State of Arkansas employs one scenario event along the New Madrid Fault. The scenario consists of a M_w7.7 earthquake along the southwest extension of the presumed New Madrid Fault system. The ground motions used to represent this seismic event were developed by the U.S. Geological Survey

(USGS) for the middle fault in the proposed New Madrid Seismic Zone (NMSZ). Each fault line is presumed to consist of three fault segments; northern, central and southern. Based on the recommendation of the Arkansas State Geologic Survey the southwest segment of the middle fault is taken as the worst case scenario for the State of Arkansas.

As with Alabama, residential structures and wood construction are the most prevalent types on buildings in Arkansas. Of the roughly 50,000 completely damaged buildings 98% are residential structures. Over 70% of all completely damaged buildings are single family homes. An additional 61,500 buildings incur moderate or severe damage. Approximately 60,000 of these buildings are residential structures, which contributes to over 110,000 residential buildings with moderate or more severe damage. All cases of complete damage occur in the 34 critical counties and nearly all moderate and severe damage occurs there as well. With this much damage concentrated in the northeast corner of Arkansas many residents will be displaced.

Table 60: Damage by General Occupancy Type for the State of Arkansas

General Occupancy Type Damage (State level)			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	936,609	38,644	35,742
Other Residential	195,818	21,792	13,626
Commercial	8,078	796	555
Industrial	1,461	155	174
Other	1,169	102	62
Total	1,143,135	61,489	50,159

Table 61: Damage by General Occupancy Type for the 34 Critical Counties

General Occupancy Type Damage (34 Critical Counties)			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	462,154	38,342	35,742
Other Residential	93,812	20,287	13,626
Commercial	4,406	781	555
Industrial	815	153	174
Other	706	96	62
Total	561,893	59,659	50,159

Wood buildings comprise a much greater proportion of total building damage in Arkansas than they did in Alabama. Nearly 60% of all complete damage occurs in wood buildings and over 50% of all moderate and more severe damage cases. Mobile homes and unreinforced masonry contribute almost entirely to the remaining damage. Roughly 30,000 cases of at least moderate damage are attributed to mobile homes and another 20,000 attributed to unreinforced masonry buildings. Steel, concrete, precast concrete and reinforced masonry contribute only a small portion of damage cases at each severity level, largely due to the lack of inventory.

Table 62: Building Damage by Building Type for State of Arkansas

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	718,424	58,893	22,688	6,744	28,425
Steel	2,398	295	218	152	332
Concrete	776	92	58	47	81
Precast	820	97	89	53	100
Reinforced Masonry	444	35	33	28	65
Unreinforced Masonry	96,398	13,474	7,340	4,011	9,334
Mobile Home	115,965	23,376	12,704	7,324	11,822
Total	935,225	96,262	43,130	18,359	50,159

Essential facilities include hospitals, schools, emergency operation centers (EOCs), police stations and fire stations. The severe shaking in eastern Arkansas counties generates numerous cases of damage to essential facilities. Of the 1,330 fire stations in the State of Arkansas, 151 are at least moderately damaged with 63 of those being completely damaged. All of these damaged facilities are located in the 34 critical counties in the northeast portion of the state. Nearly 200 school and 100 police stations are at least moderately damage. This equates to roughly 15% of all schools and 20% of all police stations in Arkansas.

The operational capabilities of essential facilities are also reduced, particularly in the 34 critical counties. Within northeastern Arkansas alone, nearly 200 fire stations and 250 schools are not functioning the day after the earthquake. Additionally, over 100 police stations are not operational. Limited functionality of facilities will likely limit the emergency services provided by firefighters and law enforcement officers in the chaotic aftermath of a catastrophic earthquake. Furthermore, schools that are frequently used as public shelters will not be available in some of the heavily damaged areas.

Table 63: Essential Facilities Damage & Functionality for the State of Arkansas [3]

Essential Facilities Damage & Functionality (State)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	103	18	10	63
Schools	1,254	188	106	995
EOCs	11	1	1	10
Police Stations	515	94	43	398
Fire Stations	1,330	151	63	1,139

[3] For Tables 63-73 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Table 64: Essential Facilities Damage & Functionality for the 34 Critical Counties

Essential Facilities Damage & Functionality (34 Critical Counties)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	49	18	10	10
Schools	613	188	106	353
EOCs	5	1	1	4
Police Stations	267	94	43	150
Fire Stations	575	151	63	384

Damage to transportation lifelines is most substantial in northeast Arkansas and the 34 critical counties. Nearly 700 bridges incur at least moderate damage while nearly 300 of those are completely damaged. Nearly 700 bridges are not functioning at full capacity immediately after the earthquake due to the extensive structural damage to bridges in the areas of most intense shaking. The remaining bridges are largely unaffected. Airport damage follows a trend similar to that of bridges. All damaged airport facilities are located in the critical counties, with 36 at least moderately damaged airports. In addition, numerous ports and railway facilities in the northeast portion of the state are damaged and not functioning in the immediate aftermath of the earthquake.

Table 65: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Bridges	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
34 Critical Counties	2,883	688	290	2,197
Remaining Counties	2,751	0	0	2,751
Total State	5,634	688	290	4,948

Table 66: Airport Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Airports	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
34 Critical Counties	172	36	5	156
Remaining Counties	142	0	0	142
Total State	314	36	5	298

Table 67: Transportation System Damage for State of Arkansas

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	2,808	0	0	2,808
	Bridges	5,634	688	290	4,948
	Tunnels	2	0	0	2
Railways	Segments	3,460	0	0	3,460
	Bridges	48	4	0	44
	Tunnels	0	0	0	0
	Facilities	68	14	0	58
Bus	Facilities	16	1	0	16
Light Rail	Segments	0	0	0	0
	Bridges	0	0	0	0
	Facilities	0	0	0	0
Ferry	Facilities	1	1	1	0
Port	Facilities	99	17	7	88
Airport	Facilities	314	36	5	298
	Runways	238	0	0	238

Communication and waste water facilities incur the most cases of damage with approximately 60 at least moderately damaged facilities each. All cases of damage occur in the critical counties, severely inhibiting the operation of these facilities and other utility facilities in the same area. Nearly 125 waste water facilities are not operating the day after the earthquake. Another 30 communication facilities and 10 electric power facilities are not functioning over the same period of time. This loss of functionality will inhibit the services provided to residents in the areas with the most sever damage.

Table 68: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
34 Critical Counties	31	2	1	29
Remaining Counties	38	0	0	38
Total State	69	2	1	67

Table 69: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
34 Critical Counties	229	66	6	105
Remaining Counties	182	0	0	182
Total State	411	66	6	287

Table 70: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
34 Critical Counties	18	2	0	16
Remaining Counties	79	0	0	79
Total State	97	2	0	95

Table 71: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
34 Critical Counties	5	2	0	2
Remaining Counties	5	0	0	5
Total State	10	2	0	7

Table 72: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
34 Critical Counties	29	8	1	18
Remaining Counties	27	0	0	27
Total State	56	8	1	45

Table 73: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
34 Critical Counties	284	59	5	253
Remaining Counties	341	0	0	341
Total State	625	59	5	594

There are several hundred thousand miles of local distribution lines in the State of Arkansas and many networks in the critical counties are severely impacted. Potable water lines show the greatest amount of both breaks and leaks at over 29,500 and 19,500, respectively. Local natural gas lines, however; show the greatest break and leak rates per length of pipe at roughly 0.22 leaks/mile (1 leak every 4.6 miles) or 0.32 breaks/mile (roughly 1 break every 3.1 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of 16,756 leaks and 26,481 breaks over the combined length of 86,153 miles of natural gas pipeline.

Potable water service is cut off for over 175,000 residences the day after the scenario earthquake. This is reduced to 171,200 residences within a week and nearly 80,000 customers are still without service after three months. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. This period of time without water prevents tens of thousands of people from remaining in their homes in the weeks and months following the earthquake. Electric power service shows similar trends, with about 95,000 service outages the day after the earthquake, or over 9% of all state residences. Even a month after the earthquake over 13,500 residences are still without power. Electric power lines are presumed to be above ground and less likely to incur damage from moderate ground shaking unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation.

Table 74: Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	191,084	19,677	29,763
Waste Water - Local	114,650	15,563	23,540
Natural Gas - Regional	9,719	393	1,317
Natural Gas - Local	76,434	16,636	25,164
Oil - Regional	2,171	89	335

Table 75: Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	1,042,696	175,565	174,382	171,216	132,672	79,737
Electric Power		95,309	68,561	39,398	13,541	112

A NOTE ON THE DETERMINATION OF DAMAGE TO INFRASTRUCTURE:

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in the report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county.

The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as discussed in footnote (3) and employed for the preceding damage tables. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Mississippi County, Arkansas – 147 Highway Bridges
  - Estimation procedure according to footnote 3:
    - Summation of individual facilities after that facility is deemed ‘damaged’ or ‘undamaged’ based on 50% or greater damage likelihood requirement estimates **147 at least moderately damaged highway bridges**
  - Estimation procedure according to topic damage tables in this appendix:
    - To determine the percentage of waste water facilities in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of facilities in that county
    - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **133 at least moderately damaged highway bridges**

In the case of Mississippi County, Arkansas, the topic damage tables in this appendix provide a lower estimate of damage as opposed to the facility-by-facility damage summation detailed in footnote (3). Though not illustrated here, other counties in Arkansas are estimated to incur greater damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged highway bridges for the 34 critical counties in Arkansas shows the following:

  - Total number of at least moderately damaged highway bridges according to the HAZUS-MH MR2 procedure for averaging damage at the county level
    - **774 at least moderately damaged highway bridges**
  - Total number of at least moderately damaged highway bridges according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
    - **688 at least moderately damaged highway bridges**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces greater damage when summed for the 34 critical counties. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix for the NMSZ scenario in Arkansas.

The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Arkansas. These tables employ the HAZUS-MH MR2 damage methodology of averaging each of the four damage levels for a county.

Table 76: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Arkansas						
Single Family	6,984	950	119	5	0	8,058
Other Residential	288	266	322	489	90	1,455
Commercial	14	15	13	9	3	54
Industrial	2	2	2	2	0	8
Other	3	2	3	2	0	10
Baxter						
Single Family	16,077	102	7	0	0	16,186
Other Residential	3,391	317	39	0	0	3,747
Commercial	119	3	0	0	0	122
Industrial	28	1	0	0	0	29
Other	15	0	0	0	0	15
Clay						
Single Family	1,726	2,883	1,356	296	1,225	7,486
Other Residential	15	83	281	306	234	919
Commercial	0	3	9	8	6	26
Industrial	0	1	2	2	2	7
Other	0	0	1	1	0	2
Cleburne						
Single Family	10,485	227	25	1	0	10,738
Other Residential	2,588	492	182	4	0	3,266
Commercial	80	3	0	0	0	83
Industrial	21	1	0	0	0	22
Other	9	0	0	0	0	9
Cleveland						
Single Family	2,615	356	44	2	0	3,017
Other Residential	434	367	205	5	0	1,011
Commercial	2	1	0	0	0	3
Industrial	1	0	0	0	0	1
Other	2	0	0	0	0	2
Craighead						
Single Family	2,179	9,693	8,301	1,726	6,021	27,920
Other Residential	91	432	907	1,193	1,974	4,597
Commercial	0	6	68	135	212	421
Industrial	0	2	12	27	56	97
Other	0	2	4	9	18	33
Crittenden						
Single Family	3,680	5,062	1,995	434	4,371	15,542
Other Residential	148	182	240	559	1,812	2,941
Commercial	1	4	21	32	74	132
Industrial	0	0	1	3	19	23
Other	1	2	3	3	10	19

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Cross						
Single Family	1,647	1,994	717	175	1,327	5,860
Other Residential	37	51	215	528	1,169	2,000
Commercial	0	2	9	12	19	42
Industrial	0	0	0	1	4	5
Other	1	1	2	4	7	15
Desha						
Single Family	4,565	466	58	3	0	5,092
Other Residential	621	323	169	4	0	1,117
Commercial	28	10	4	0	0	42
Industrial	8	2	1	0	0	11
Other	9	3	1	0	0	13
Faulkner						
Single Family	25,441	162	11	0	0	25,614
Other Residential	6,920	599	73	0	0	7,592
Commercial	230	6	1	0	0	237
Industrial	83	2	0	0	0	85
Other	55	1	0	0	0	56
Fulton						
Single Family	4,834	31	2	0	0	4,867
Other Residential	1,162	113	14	0	0	1,289
Commercial	25	1	0	0	0	26
Industrial	13	0	0	0	0	13
Other	4	0	0	0	0	4
Grant						
Single Family	4,954	174	20	1	0	5,149
Other Residential	1,668	405	169	4	0	2,246
Commercial	16	0	0	0	0	16
Industrial	3	0	0	0	0	3
Other	2	0	0	0	0	2
Greene						
Single Family	1,181	5,117	4,281	839	1,961	13,379
Other Residential	32	214	727	828	760	2,561
Commercial	1	9	30	28	26	94
Industrial	0	0	2	4	7	13
Other	0	1	2	2	1	6
Independence						
Single Family	10,526	1,432	179	8	0	12,145
Other Residential	1,341	1,079	599	14	0	3,033
Commercial	61	26	11	1	0	99
Industrial	3	2	1	0	0	6
Other	5	2	1	0	0	8

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Izard						
Single Family	5,057	32	2	0	0	5,091
Other Residential	1,336	131	16	0	0	1,483
Commercial	45	1	0	0	0	46
Industrial	5	0	0	0	0	5
Other	7	0	0	0	0	7
Jackson						
Single Family	2,218	2,082	580	179	1,542	6,601
Other Residential	75	135	312	298	256	1,076
Commercial	1	6	17	13	17	54
Industrial	0	0	0	0	0	0
Other	0	0	1	2	1	4
Jefferson						
Single Family	24,397	3,319	414	19	0	28,149
Other Residential	2,288	1,647	895	22	0	4,852
Commercial	120	51	21	1	0	193
Industrial	19	9	4	0	0	32
Other	25	9	3	0	0	37
Lawrence						
Single Family	3,696	1,725	427	120	1,149	7,117
Other Residential	304	272	209	74	79	938
Commercial	2	4	8	6	7	27
Industrial	1	0	1	1	1	4
Other	0	0	1	1	1	3
Lee						
Single Family	1,132	1,062	296	91	885	3,466
Other Residential	42	90	241	233	253	859
Commercial	0	1	3	2	3	9
Industrial	0	0	0	0	0	0
Other	0	0	1	0	1	2
Lincoln						
Single Family	2,950	401	50	2	0	3,403
Other Residential	713	583	325	8	0	1,629
Commercial	9	4	1	0	0	14
Industrial	2	1	1	0	0	4
Other	4	1	1	0	0	6
Lonoke						
Single Family	14,602	2,531	307	14	130	17,584
Other Residential	1,871	1,470	864	176	88	4,469
Commercial	38	20	10	4	1	73
Industrial	8	4	4	3	1	20
Other	9	4	1	0	0	14

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Mississippi						
Single Family	89	636	3,231	4,251	8,327	16,534
Other Residential	3	29	196	408	3,517	4,153
Commercial	0	0	0	2	108	110
Industrial	0	0	0	0	19	19
Other	0	0	0	0	14	14
Monroe						
Single Family	2,565	838	192	50	10	3,655
Other Residential	163	194	300	370	66	1,093
Commercial	3	4	7	5	1	20
Industrial	1	1	1	1	0	4
Other	1	1	2	1	0	5
Phillips						
Single Family	5,494	1,198	231	52	1,417	8,392
Other Residential	394	247	254	345	325	1,565
Commercial	9	10	12	8	9	48
Industrial	1	1	1	1	2	6
Other	2	2	2	2	1	9
Poinsett						
Single Family	521	1,658	1,996	1,110	3,458	8,743
Other Residential	6	43	128	284	1,433	1,894
Commercial	0	0	2	5	44	51
Industrial	0	0	0	1	46	47
Other	0	0	1	1	5	7
Prairie						
Single Family	3,237	440	55	3	0	3,735
Other Residential	187	201	250	382	71	1,091
Commercial	4	4	3	2	1	14
Industrial	0	0	1	1	0	2
Other	3	2	2	2	0	9
Pulaski						
Single Family	115,814	12,843	1,564	71	2	130,294
Other Residential	9,898	3,781	1,792	45	0	15,516
Commercial	1,338	418	171	12	0	1,939
Industrial	153	61	33	3	0	250
Other	238	71	26	1	0	336
Randolph						
Single Family	4,493	1,661	381	100	470	7,105
Other Residential	419	369	224	43	112	1,167
Commercial	3	4	9	6	2	24
Industrial	1	1	5	6	2	15
Other	1	0	1	1	0	3

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Saint Francis						
Single Family	3,129	2,936	818	254	1,019	8,156
Other Residential	127	252	674	714	496	2,263
Commercial	1	6	17	12	8	44
Industrial	0	3	9	9	10	31
Other	1	1	1	0	0	3
Sharp						
Single Family	7,318	720	89	4	0	8,131
Other Residential	864	312	151	3	0	1,330
Commercial	39	15	6	0	0	60
Industrial	3	1	1	0	0	5
Other	7	2	1	0	0	10
Stone						
Single Family	4,328	28	2	0	0	4,358
Other Residential	1,275	125	15	0	0	1,415
Commercial	46	1	0	0	0	47
Industrial	7	0	0	0	0	7
Other	10	0	0	0	0	10
Van Buren						
Single Family	6,875	44	3	0	0	6,922
Other Residential	1,859	179	22	0	0	2,060
Commercial	41	1	0	0	0	42
Industrial	9	0	0	0	0	9
Other	16	0	0	0	0	16
White						
Single Family	16,279	2,172	363	61	1,618	20,493
Other Residential	2,723	1,543	1,102	427	681	6,476
Commercial	117	37	17	3	11	185
Industrial	14	7	4	1	4	30
Other	9	2	1	0	1	13
Woodruff						
Single Family	1,035	972	271	84	810	3,172
Other Residential	24	66	206	203	210	709
Commercial	0	1	3	2	3	9
Industrial	0	0	0	1	1	2
Other	0	0	1	1	2	4

Table 77: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Arkansas	74	13	17.00	13	17.50	29	39.80	64	86.60	69	93.20
Baxter	268	258	96.40	259	96.50	266	99.30	268	99.90	268	99.90
Clay	25	0	0.40	0	0.40	1	2.60	7	28.80	14	55.20
Cleburne	25	24	96.40	24	96.50	25	99.30	25	99.90	25	99.90
Cleveland	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Craighead	594	0	0.00	0	0.00	0	0.00	12	2.00	82	13.80
Crittenden	152	0	0.00	0	0.00	0	0.00	2	1.60	17	10.90
Cross	15	0	0.00	0	0.00	0	0.00	0	1.60	2	10.90
Desha	60	43	72.05	43	72.40	52	86.45	59	98.75	60	99.35
Faulkner	149	144	96.40	144	96.50	148	99.30	149	99.90	149	99.90
Fulton	25	24	96.40	24	96.50	25	99.30	25	99.90	25	99.90
Grant	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Greene	129	0	0.00	0	0.00	0	0.00	3	2.00	18	13.80
Independence	185	88	47.70	89	48.30	136	73.60	181	97.60	183	98.80
Izard	25	24	96.40	24	96.50	25	99.30	25	99.90	25	99.90
Jackson	133	0	0.30	0	0.30	3	2.00	30	22.60	58	43.60
Jefferson	446	213	47.70	215	48.30	328	73.60	435	97.60	441	98.80
Lawrence	25	0	0.30	0	0.30	1	2.00	6	22.60	11	43.60
Lee	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Lincoln	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Lonoke	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Mississippi	193	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Monroe	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Phillips	155	20	12.70	20	13.10	46	29.80	101	65.00	108	69.90
Poinsett	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Prairie	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Pulaski	3,888	1993	51.26	2015	51.82	2934	75.47	3801	97.77	3845	98.88
Randolph	50	0	0.40	0	0.50	1	2.70	15	30.20	29	58.10
St. Francis	118	0	0.40	0	0.40	3	2.60	34	29.10	66	56.10
Sharp	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Stone	25	24	96.40	24	96.50	25	99.30	25	99.90	25	99.90
Van Buren	25	24	96.40	24	96.50	25	99.30	25	99.90	25	99.90
White	438	209	47.70	212	48.30	322	73.60	427	97.60	433	98.80
Woodruff	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

Table 78: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Arkansas	8	51.90
Baxter	6	94.10
Clay	5	0.56
Cleburne	6	80.03
Cleveland	3	51.90
Craighead	13	0.09
Crittenden	14	0.14
Cross	4	0.25
Desha	10	56.12
Faulkner	10	94.10
Fulton	4	94.10
Grant	2	94.10
Greene	4	0.50
Independence	2	51.90
Izard	3	94.10
Jackson	8	0.60
Jefferson	12	51.90
Lawrence	5	21.12
Lee	2	0.60
Lincoln	4	51.90
Lonoke	9	49.58
Mississippi	12	0.00
Monroe	6	34.90
Phillips	6	36.85
Poinsett	7	0.07
Prairie	4	51.90
Pulaski	57	53.74
Randolph	3	0.70
St. Francis	8	0.65
Sharp	7	63.96
Stone	2	94.10
Van Buren	3	94.10
White	12	47.08
Woodruff	6	0.60

Table 79: School Functionality

Counties	Count	Functionality At Day 1 (%)
Arkansas	13	51.90
Baxter	10	94.10
Clay	7	0.43
Cleburne	12	83.55
Cleveland	5	51.90
Craighead	39	0.06
Crittenden	27	0.30
Cross	7	0.29
Desha	10	68.78
Faulkner	38	94.10
Fulton	5	94.10
Grant	6	94.10
Greene	17	0.20
Independence	20	51.90
Izard	9	94.10
Jackson	7	0.60
Jefferson	40	51.90
Lawrence	14	29.39
Lee	7	6.07
Lincoln	3	51.90
Lonoke	22	48.72
Mississippi	30	0.00
Monroe	5	31.50
Phillips	15	39.86
Poinsett	14	0.07
Prairie	5	51.90
Pulaski	142	57.37
Randolph	10	22.10
St. Francis	13	0.62
Sharp	8	73.00
Stone	6	94.10
Van Buren	8	94.10
White	34	52.38
Woodruff	5	0.60

Table 80: Fire Station Functionality

Counties	Count	Functionality At Day 1 (%)
Arkansas	13	51.90
Baxter	25	94.10
Clay	11	0.49
Cleburne	19	82.99
Cleveland	10	51.90
Craighead	24	0.19
Crittenden	17	0.24
Cross	7	0.21
Desha	9	65.97
Faulkner	28	94.10
Fulton	13	94.10
Grant	11	82.59
Greene	11	0.38
Independence	19	51.22
Izard	12	94.10
Jackson	12	0.60
Jefferson	23	51.90
Lawrence	14	25.20
Lee	6	0.60
Lincoln	11	51.90
Lonoke	23	49.23
Mississippi	19	0.00
Monroe	7	44.61
Phillips	12	42.21
Poinsett	9	0.17
Prairie	14	50.04
Pulaski	68	62.35
Randolph	11	32.99
St. Francis	8	0.61
Sharp	17	66.79
Stone	22	94.10
Van Buren	24	94.10
White	40	44.16
Woodruff	6	0.60

Table 81: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Arkansas	8	93.20	98.90	99.40	99.90	99.90
Baxter	12	98.15	99.65	99.78	99.90	99.90
Clay	5	59.10	77.26	81.76	92.10	98.54
Cleburne	4	93.20	98.90	99.40	99.90	99.90
Cleveland	0	0.00	0.00	0.00	0.00	0.00
Craighead	18	50.37	72.41	79.09	93.68	98.83
Crittenden	9	48.64	66.72	72.39	86.64	97.59
Cross	4	51.13	71.65	77.68	91.45	98.45
Desha	4	98.15	99.65	99.78	99.90	99.90
Faulkner	8	98.15	99.65	99.78	99.90	99.90
Fulton	2	93.20	98.90	99.40	99.90	99.90
Grant	9	95.40	99.23	99.57	99.90	99.90
Greene	4	53.30	76.30	82.80	96.30	99.30
Independence	29	91.12	98.18	98.90	99.81	99.89
Izard	2	93.20	98.90	99.40	99.90	99.90
Jackson	2	76.25	91.35	93.45	97.45	99.50
Jefferson	23	93.20	98.90	99.40	99.90	99.90
Lawrence	8	74.10	88.70	90.80	95.40	99.10
Lee	2	74.10	88.70	90.80	95.40	99.10
Lincoln	1	93.20	98.90	99.40	99.90	99.90
Lonoke	6	93.20	98.90	99.40	99.90	99.90
Mississippi	12	24.63	35.57	44.74	71.48	94.92
Monroe	2	78.40	94.00	96.10	99.50	99.90
Phillips	7	77.17	92.49	94.59	98.33	99.67
Poinsett	5	29.56	43.90	53.12	78.08	96.10
Prairie	2	74.10	88.70	90.80	95.40	99.10
Pulaski	62	96.61	99.42	99.66	99.90	99.90
Randolph	4	77.33	92.68	94.78	98.48	99.70
St. Francis	4	63.23	83.53	87.68	96.13	99.28
Sharp	3	93.20	98.90	99.40	99.90	99.90
Stone	8	93.20	98.90	99.40	99.90	99.90
Van Buren	3	99.80	99.90	99.90	99.90	99.90
White	11	83.00	94.82	96.34	98.90	99.75
Woodruff	1	74.10	88.70	90.80	95.40	99.10

Table 82: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Arkansas	8,457	0.00	0.00	0.00	0.00	0.00
Baxter	17,052	0.00	0.00	0.00	0.00	0.00
Clay	7,417	97.90	97.64	96.98	83.43	0.00
Cleburne	10,190	0.00	0.00	0.00	0.00	0.00
Cleveland	3,273	0.00	0.00	0.00	0.00	0.00
Craighead	32,301	99.78	99.77	99.75	99.54	96.69
Crittenden	18,471	99.87	99.86	99.84	99.68	95.50
Cross	7,391	99.81	99.80	99.77	99.34	23.43
Desha	5,922	0.00	0.00	0.00	0.00	0.00
Faulkner	31,882	0.00	0.00	0.00	0.00	0.00
Fulton	4,810	0.00	0.00	0.00	0.00	0.00
Grant	6,241	0.00	0.00	0.00	0.00	0.00
Greene	14,750	98.81	98.69	98.41	94.14	0.00
Independence	13,467	0.00	0.00	0.00	0.00	0.00
Izard	5,440	0.00	0.00	0.00	0.00	0.00
Jackson	6,971	97.04	96.61	95.50	63.29	0.00
Jefferson	30,555	0.00	0.00	0.00	0.00	0.00
Lawrence	7,108	90.49	88.51	82.75	0.00	0.00
Lee	4,182	98.18	97.92	97.25	78.12	0.00
Lincoln	4,265	0.00	0.00	0.00	0.00	0.00
Lonoke	19,262	0.00	0.00	0.00	0.00	0.00
Mississippi	19,349	99.94	99.94	99.93	99.90	99.61
Monroe	4,105	0.00	0.00	0.00	0.00	0.00
Phillips	9,711	86.58	84.23	77.84	0.00	0.00
Poinsett	10,026	99.90	99.89	99.88	99.79	98.34
Prairie	3,894	0.00	0.00	0.00	0.00	0.00
Pulaski	147,942	0.00	0.00	0.00	0.00	0.00
Randolph	7,265	81.36	77.14	64.69	0.00	0.00
St. Francis	10,043	98.76	98.65	98.38	94.81	0.00
Sharp	7,211	0.00	0.00	0.00	0.00	0.00
Stone	4,768	0.00	0.00	0.00	0.00	0.00
Van Buren	6,825	0.00	0.00	0.00	0.00	0.00
White	25,148	84.76	83.16	79.30	21.29	0.00
Woodruff	3,531	98.19	97.93	97.28	79.33	0.00

Table 83: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Arkansas	1	50.0%	37.6%	11.4%	1.0%	0.1%
Baxter	1	50.0%	37.6%	11.4%	1.0%	0.1%
Clay	0	0.0%	0.0%	0.0%	0.0%	0.0%
Cleburne	1	50.0%	37.6%	11.4%	1.0%	0.1%
Cleveland	0	0.0%	0.0%	0.0%	0.0%	0.0%
Craighead	0	0.0%	0.0%	0.0%	0.0%	0.0%
Crittenden	0	0.0%	0.0%	0.0%	0.0%	0.0%
Cross	0	0.0%	0.0%	0.0%	0.0%	0.0%
Desha	0	0.0%	0.0%	0.0%	0.0%	0.0%
Faulkner	3	50.0%	37.6%	11.4%	1.0%	0.1%
Fulton	0	0.0%	0.0%	0.0%	0.0%	0.0%
Grant	2	73.3%	20.4%	5.8%	0.5%	0.0%
Greene	0	0.0%	0.0%	0.0%	0.0%	0.0%
Independence	1	49.6%	37.3%	11.3%	1.0%	0.8%
Izard	1	50.0%	37.6%	11.4%	1.0%	0.1%
Jackson	2	18.4%	39.3%	28.7%	6.1%	7.6%
Jefferson	2	50.0%	37.6%	11.4%	1.0%	0.1%
Lawrence	0	0.0%	0.0%	0.0%	0.0%	0.0%
Lee	0	0.0%	0.0%	0.0%	0.0%	0.0%
Lincoln	0	0.0%	0.0%	0.0%	0.0%	0.0%
Lonoke	3	50.0%	37.6%	11.4%	1.0%	0.1%
Mississippi	2	0.3%	4.5%	19.9%	33.2%	42.1%
Monroe	1	19.7%	42.2%	30.8%	6.6%	0.7%
Phillips	0	0.0%	0.0%	0.0%	0.0%	0.0%
Poinsett	0	0.0%	0.0%	0.0%	0.0%	0.0%
Prairie	0	0.0%	0.0%	0.0%	0.0%	0.0%
Pulaski	7	50.0%	37.6%	11.4%	1.0%	0.1%
Randolph	0	0.0%	0.0%	0.0%	0.0%	0.0%
St. Francis	0	0.0%	0.0%	0.0%	0.0%	0.0%
Sharp	0	0.0%	0.0%	0.0%	0.0%	0.0%
Stone	1	50.0%	37.6%	11.4%	1.0%	0.1%
Van Buren	0	0.0%	0.0%	0.0%	0.0%	0.0%
White	3	29.4%	39.7%	23.6%	4.5%	2.8%
Woodruff	0	0.0%	0.0%	0.0%	0.0%	0.0%

Table 84: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Arkansas	2,019	87	22
Baxter	1,634	9	2
Clay	1,342	541	1,244
Cleburne	1,390	8	2
Cleveland	995	24	6
Craighead	2,085	2,094	3,852
Crittenden	1,552	1,828	3,306
Cross	1,212	1,033	2,355
Desha	1,266	48	12
Faulkner	1,828	10	2
Fulton	1,345	7	2
Grant	1,453	8	2
Greene	1,472	669	1,648
Independence	1,567	22	5
Izard	1,267	7	2
Jackson	1,234	411	1,015
Jefferson	2,429	90	23
Lawrence	1,143	225	586
Lee	1,122	418	1,100
Lincoln	1,102	47	12
Lonoke	1,993	74	34
Mississippi	2,082	6,307	5,503
Monroe	1,069	123	31
Phillips	1,446	280	622
Poinsett	1,716	3,179	3,944
Prairie	1,297	56	14
Pulaski	3,414	38	10
Randolph	1,233	139	449
St. Francis	1,633	754	1,798
Sharp	1,387	8	2
Stone	1,104	6	2
Van Buren	1,543	8	2
White	2,388	326	945
Woodruff	1,141	425	1,119

Table 85: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Arkansas	8,457	0.00	0.00	0.00	0.00	0.00
Baxter	17,052	0.00	0.00	0.00	0.00	0.00
Clay	7,417	49.79	30.24	12.00	2.74	0.07
Cleburne	10,190	0.00	0.00	0.00	0.00	0.00
Cleveland	3,273	0.00	0.00	0.00	0.00	0.00
Craighead	32,301	83.37	56.82	28.43	8.55	0.10
Crittenden	18,471	81.20	55.59	30.85	11.14	0.10
Cross	7,391	76.94	48.21	24.00	8.48	0.09
Desha	5,922	0.00	0.00	0.00	0.00	0.00
Faulkner	31,882	0.00	0.00	0.00	0.00	0.00
Fulton	4,810	0.00	0.00	0.00	0.00	0.00
Grant	6,241	0.00	0.00	0.00	0.00	0.00
Greene	14,750	80.47	51.11	22.31	5.88	0.10
Independence	13,467	0.00	0.00	0.00	0.00	0.00
Izard	5,440	0.00	0.00	0.00	0.00	0.00
Jackson	6,971	0.00	0.00	0.00	0.00	0.00
Jefferson	30,555	0.00	0.00	0.00	0.00	0.00
Lawrence	7,108	0.00	0.00	0.00	0.00	0.00
Lee	4,182	0.00	0.00	0.00	0.00	0.00
Lincoln	4,265	0.00	0.00	0.00	0.00	0.00
Lonoke	19,262	0.00	0.00	0.00	0.00	0.00
Mississippi	19,349	94.93	84.98	63.88	24.83	0.10
Monroe	4,105	0.00	0.00	0.00	0.00	0.00
Phillips	9,711	0.00	0.00	0.00	0.00	0.00
Poinsett	10,026	91.19	75.58	51.56	19.01	0.10
Prairie	3,894	0.00	0.00	0.00	0.00	0.00
Pulaski	147,942	0.00	0.00	0.00	0.00	0.00
Randolph	7,265	0.00	0.00	0.00	0.00	0.00
St. Francis	10,043	46.02	25.64	10.27	3.12	0.06
Sharp	7,211	0.00	0.00	0.00	0.00	0.00
Stone	4,768	0.00	0.00	0.00	0.00	0.00
Van Buren	6,825	0.00	0.00	0.00	0.00	0.00
White	25,148	0.00	0.00	0.00	0.00	0.00
Woodruff	3,531	0.00	0.00	0.00	0.00	0.00

Table 86: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Arkansas	6	50.0%	37.6%	11.4%	1.0%	0.1%
Baxter	4	71.6%	22.0%	5.9%	0.5%	0.0%
Clay	10	8.5%	26.6%	33.4%	14.6%	17.0%
Cleburne	2	50.0%	37.6%	11.4%	1.0%	0.1%
Cleveland	3	89.8%	9.4%	0.7%	0.0%	0.0%
Craighead	11	2.4%	15.4%	33.8%	24.6%	23.8%
Crittenden	9	3.5%	17.7%	33.3%	22.1%	23.5%
Cross	5	4.3%	20.8%	34.7%	18.8%	21.3%
Desha	6	57.8%	31.9%	9.5%	0.8%	0.1%
Faulkner	8	85.0%	11.8%	3.0%	0.2%	0.0%
Fulton	2	50.0%	37.6%	11.4%	1.0%	0.1%
Grant	2	96.6%	3.2%	0.2%	0.0%	0.0%
Greene	4	3.2%	19.5%	37.7%	21.5%	18.1%
Independence	4	18.7%	40.0%	29.2%	6.2%	5.9%
Izard	6	50.0%	37.6%	11.4%	1.0%	0.1%
Jackson	8	18.4%	39.3%	28.7%	6.1%	7.6%
Jefferson	9	50.0%	37.6%	11.4%	1.0%	0.1%
Lawrence	9	18.7%	39.9%	29.2%	6.2%	6.1%
Lee	4	18.4%	39.3%	28.7%	6.1%	7.6%
Lincoln	3	50.0%	37.6%	11.4%	1.0%	0.1%
Lonoke	8	50.0%	37.6%	11.3%	1.0%	0.2%
Mississippi	15	0.2%	2.8%	16.7%	35.0%	45.3%
Monroe	3	19.7%	42.2%	30.8%	6.6%	0.7%
Phillips	7	22.9%	39.0%	26.2%	5.4%	6.5%
Poinsett	9	2.6%	11.6%	23.1%	26.7%	36.0%
Prairie	5	43.9%	38.5%	15.2%	2.1%	0.2%
Pulaski	28	51.7%	36.4%	11.0%	0.9%	0.1%
Randolph	5	18.9%	40.4%	29.5%	6.3%	4.8%
St. Francis	8	10.2%	31.0%	33.2%	11.0%	14.7%
Sharp	3	50.0%	37.6%	11.4%	1.0%	0.1%
Stone	1	50.0%	37.6%	11.4%	1.0%	0.1%
Van Buren	6	57.8%	31.9%	9.5%	0.8%	0.1%
White	12	26.5%	39.3%	24.7%	4.9%	4.6%
Woodruff	4	18.4%	39.3%	28.7%	6.1%	7.6%

Table 87: Waste Water Pipeline Damage

Counties	Length (km)	Total Number of Leaks	Total Number of Breaks
Arkansas	1,212	69	17
Baxter	981	7	2
Clay	805	428	984
Cleburne	834	6	2
Cleveland	597	19	5
Craighead	1,251	1,656	3,046
Crittenden	931	1,445	2,615
Cross	727	817	1,863
Desha	759	38	10
Faulkner	1,097	8	2
Fulton	807	6	1
Grant	872	6	2
Greene	883	529	1,303
Independence	941	17	4
Izard	760	5	1
Jackson	740	325	803
Jefferson	1,457	71	18
Lawrence	686	178	463
Lee	673	330	870
Lincoln	661	37	9
Lonoke	1,196	58	27
Mississippi	1,249	4,988	4,352
Monroe	641	97	24
Phillips	868	222	492
Poinsett	1,030	2,514	3,119
Prairie	778	44	11
Pulaski	2,049	30	8
Randolph	740	110	355
St. Francis	979	596	1,422
Sharp	832	6	1
Stone	662	5	1
Van Buren	926	7	2
White	1,433	257	748
Woodruff	685	336	885

Table 88: Highway Bridge Damage

Counties	# of Bridge	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Arkansas	61	71.92%	10.31%	6.58%	7.72%	3.44%
Baxter	24	96.36%	2.34%	0.81%	0.42%	0.06%
Clay	70	52.33%	9.30%	6.24%	7.99%	24.12%
Cleburne	31	96.72%	2.18%	0.68%	0.35%	0.05%
Cleveland	61	95.95%	3.05%	0.63%	0.31%	0.04%
Craighead	124	34.90%	6.42%	6.67%	12.56%	39.42%
Crittenden	147	21.10%	7.78%	7.27%	15.33%	48.49%
Cross	83	31.83%	7.41%	6.83%	13.12%	40.79%
Desha	37	95.41%	2.95%	1.02%	0.54%	0.08%
Faulkner	90	94.23%	3.67%	1.32%	0.67%	0.09%
Fulton	55	94.50%	3.54%	1.24%	0.62%	0.08%
Grant	74	95.35%	3.25%	0.89%	0.44%	0.06%
Greene	79	48.01%	9.84%	6.18%	8.51%	27.43%
Independence	130	92.68%	2.76%	0.64%	0.53%	3.37%
Izard	60	96.23%	2.48%	0.82%	0.41%	0.05%
Jackson	71	51.41%	8.70%	6.06%	6.79%	27.01%
Jefferson	92	96.42%	2.56%	0.63%	0.33%	0.05%
Lawrence	68	66.34%	8.25%	3.05%	3.54%	18.79%
Lee	43	55.49%	8.02%	5.39%	6.74%	24.34%
Lincoln	40	95.48%	3.39%	0.71%	0.35%	0.05%
Lonoke	117	78.18%	10.08%	4.21%	5.08%	2.44%
Mississippi	147	6.01%	3.20%	4.21%	11.50%	75.05%
Monroe	73	67.39%	11.33%	7.60%	9.42%	4.23%
Phillips	45	66.86%	8.12%	5.38%	6.30%	13.32%
Poinsett	95	12.90%	4.00%	4.99%	12.79%	65.30%
Prairie	64	66.55%	10.08%	7.04%	8.20%	8.11%
Pulaski	332	92.14%	6.34%	0.93%	0.50%	0.07%
Randolph	67	71.11%	10.93%	2.45%	3.63%	11.86%
St. Francis	120	34.20%	10.32%	8.90%	13.74%	32.82%
Sharp	63	95.36%	3.27%	0.87%	0.43%	0.06%
Stone	40	93.77%	3.70%	1.58%	0.82%	0.12%
Van Buren	48	96.19%	2.46%	0.85%	0.43%	0.06%
White	181	80.05%	4.05%	1.60%	3.22%	11.07%
Woodruff	51	55.05%	7.61%	5.23%	6.12%	25.96%

Table 89: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Arkansas	61	81.82	86.35	88.94	89.99	94.04
Baxter	24	98.31	99.14	99.46	99.51	99.71
Clay	70	61.81	65.98	68.46	69.80	75.38
Cleburne	31	98.51	99.25	99.53	99.57	99.75
Cleveland	61	98.39	99.32	99.58	99.61	99.76
Craighead	124	42.82	46.41	49.13	51.09	59.99
Crittenden	147	30.48	34.61	37.61	39.96	50.85
Cross	83	40.59	44.45	47.25	49.29	58.56
Desha	37	97.89	98.91	99.31	99.39	99.65
Faulkner	90	97.34	98.64	99.17	99.26	99.59
Fulton	55	97.48	98.73	99.22	99.31	99.61
Grant	74	98.00	99.07	99.42	99.48	99.69
Greene	79	57.96	62.25	64.73	66.14	72.22
Independence	128	94.97	95.84	96.10	96.21	96.70
Izard	60	98.28	99.13	99.46	99.51	99.71
Jackson	71	60.41	64.37	66.77	68.02	73.20
Jefferson	92	98.48	99.30	99.55	99.59	99.75
Lawrence	68	73.85	76.82	78.04	78.75	81.76
Lee	43	63.73	67.33	69.47	70.66	75.63
Lincoln	40	98.20	99.24	99.53	99.57	99.74
Lonoke	117	87.12	90.88	92.53	93.21	95.89
Mississippi	147	11.42	13.54	15.39	17.60	28.36
Monroe	73	78.43	83.51	86.50	87.77	92.72
Phillips	45	74.92	78.54	80.68	81.67	85.68
Poinsett	95	19.01	21.53	23.68	25.92	36.66
Prairie	64	76.53	81.13	83.90	85.08	89.67
Pulaski	332	97.14	99.00	99.36	99.44	99.68
Randolph	67	80.31	83.79	84.77	85.37	87.97
St. Francis	119	45.59	50.80	54.37	56.45	65.49
Sharp	63	98.03	99.10	99.44	99.50	99.70
Stone	40	96.98	98.37	98.98	99.11	99.52
Van Buren	48	98.24	99.10	99.43	99.49	99.70
White	180	83.83	85.32	85.97	86.48	88.82
Woodruff	51	62.95	66.39	68.48	69.61	74.38

Illinois – New Madrid Seismic Zone Scenario

This earthquake impact assessment includes all 102 counties in the State of Illinois. Illinois is approximately 56,000 square miles and is bordered by Wisconsin to the north, Iowa and Missouri to the west, Kentucky to the southeast, and Indiana to the east. For the purposes of this analysis, 40 critical counties have been identified in the southern portion of the state where shaking is anticipated to be most intense. These 40 counties are the focus of much of the damage assessment included within this document. The critical counties are listed below:

- Alexander
- Bond
- Calhoun
- Clark
- Clay
- Clinton
- Crawford
- Edwards
- Effingham
- Fayette
- Franklin
- Gallatin
- Greene
- Hamilton
- Hardin
- Jackson
- Jasper
- Jefferson
- Jersey
- Johnson
- Lawrence
- Macoupin
- Madison
- Marion
- Massac
- Monroe
- Montgomery
- Perry
- Pope
- Pulaski
- Randolph
- Richland
- Saint Clair
- Saline
- Union
- Wabash
- Washington
- Wayne
- White
- Williamson

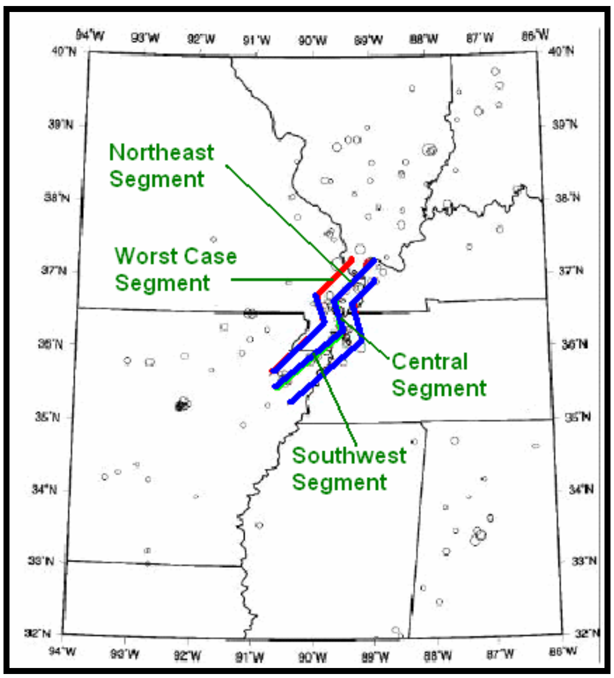

Figure 4: Location of Fault Rupture for NMSZ Scenario in the State of Illinois

The earthquake impact assessment for the State of Illinois employs one scenario event along the New Madrid Fault. The scenario consists of a M_w7.7 earthquake along the northern segment of the presumed New Madrid Fault system. The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS) for

the middle fault in the proposed New Madrid Seismic Zone (NMSZ). Each fault line is presumed to consist of three fault segments; northern, central and southern. The worst-case scenario for the State of Illinois, the critical counties in particular, is an event on the western fault line in the northern segment, as shown in Figure 4. For more information on the hazard utilized in this scenario please reference Appendix I.

The NMSZ scenario produces thousands of damaged buildings in the State of Illinois. There are nearly 17,000 cases of complete damage which are included in the nearly 30,000 at least moderately damaged buildings. As with previous state scenarios, residential buildings experience the greatest amount of damage. Nearly 99% of all complete damage occurs with residential buildings. This occupancy type also accounts for nearly 99% of at least moderate damage throughout the state. All but three completely damaged buildings are located in the 40 critical counties in southern Illinois. Additionally, 90% of all at least moderate damage occurs in these 40 critical counties.

Table 90: Damage by General Occupancy Type for the State of Illinois

General Occupancy Type Damage (State level)			
General Occupancy Type	**Total No. Buildings**	**At Least Moderate Damage**	**Complete Damage**
Single Family	2,780,853	16,999	11,586
Other Residential	416,473	12,046	5,087
Commercial	41,905	352	140
Industrial	7,466	40	11
Other	4,515	46	36
Total	3,251,212	29,483	16,860

Table 91: Damage by General Occupancy Type for the 40 Critical Counties

General Occupancy Type Damage (40 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**At Least Moderate Damage**	**Complete Damage**
Single Family	365,291	14,975	11,586
Other Residential	73,465	10,752	5,087
Commercial	3,311	240	138
Industrial	359	20	10
Other	646	45	36
Total	443,072	26,032	16,857

Wood frame construction is the most common type of building in the State of Illinois and also generates the most cases of complete damage. Nearly half of all complete damage, 7,800 buildings, is experienced by wood frame structures. Unreinforced masonry and mobile homes are estimated to incur the most cases of moderate damage with over 70% moderate damage attributed to these building types. This damage state is identified by significant cracking to unreinforced masonry walls as well as some connection damage to column/beam joints in unreinforced masonry building. The remaining building types

show far less inventory throughout the state and thus experience a far lesser proportion of damage.

Table 92: Building Damage by Building Type for the State of Illinois

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	2,315,085	21,686	6,150	2,750	7,819
Steel	16,145	656	193	15	60
Concrete	31,516	917	250	44	215
Precast	5,382	178	71	8	26
Reinforced Masonry	5,776	78	24	2	15
Unreinforced Masonry	638,209	38,777	7,430	1,176	4,117
Mobile Home	107,166	23,298	9,620	1,750	4,608
Total	3,119,279	85,590	23,738	5,745	16,860

Of the 1,725 fire stations in the state, 38 (more than 2%) are estimated to experience at least moderate damage. 60 schools are completely damaged while another 23 experience moderate or severe damage. Additionally, over 20 police stations are damaged from the NMSZ event. Two emergency operation centers are expected to sustain this level of damage since they are located in the portion of the state which experiences the most severe shaking. All damage is confined to the 40 critical counties in southern Illinois.

Not only are numerous facilities damaged but a large number of facilities are also not functional in the days immediately after the earthquake. Over 250 schools, 80 fire stations and 50 police stations are not fully functional in the days after the event. This will likely inhibit the ability of law enforcement, fire fighters and medical personnel to assist those in heavily impacted areas.

Table 93: Essential Facilities Damage & Functionality for State of Illinois[4]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities (State)**	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage>50%)**	**Functionality >50% at Day 1**
Hospitals	249	3	1	217
Schools	5,722	83	60	5,464
EOCs	149	2	2	145
Police Stations	1,044	21	15	997
Fire Stations	1,725	38	32	1,645

[4] For Tables 93-103 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Table 94: Essential Facilities Damage & Functionality for Critical Counties

Essential Facilities Damage & Functionality				
Essential Facility Type	Total No. Facilities (40 Critical Counties)	At Least Moderate Damage (Damage>50%)	Complete Damage (Damage>50%)	Functionality >50% at Day 1
Hospitals	52	3	1	20
Schools	1,167	83	60	909
EOCs	31	2	2	27
Police Stations	267	21	15	220
Fire Stations	366	38	32	286

Table 95: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. of Bridges	At Least Moderate Damage (Damage>50%)	Complete Damage (Damage>50%)	Functionality >50% at Day 1
40 Critical Counties	6,554	264	71	6,293
Remaining Counties	16,300	0	0	16,300
Total State	22,854	264	71	22,593

Table 96: Airport Damage Assessments

Airport Damage Assessments				
	Total No. of Airports	At Least Moderate Damage (Damage>50%)	Complete Damage (Damage>50%)	Functionality >50% at Day 1
40 Critical Counties	195	30	9	173
Remaining Counties	734	0	0	734
Total State	929	30	9	907

Transportation lifelines, particularly in southern Illinois, are significantly impacted by this NMSZ event. Over 70 bridges are expected to incur complete damage while over 250 experience moderate or more severe damage. Highway road segments connecting these damaged bridges are expected to incur slightly less damage than the bridges themselves, even in these counties with the most severe shaking. Highway segments are most generally defined as a section of highway between two end nodes. These end nodes are frequently highway bridges. At least moderate damage to highway bridges is characterized by moderate shear (diagonal) cracking of columns, spalling of cover concrete and shear keys, abutment movement less than two-inches, extensive cracking to shear keys, bent connection bolts and moderate settlement of the bridge approaches. Many airports, ports and railway facilities in southern Illinois incur moderate damage, greatly impeding the operation of these facilities. At least moderate damage to port facilities includes considerable ground settlement, derailment of port equipment and damage to structural members. For airports, at least moderate damage is defined in the same manner as damage to other building types discussed previously. The lack of functionality of many transportation lifelines in southern Illinois will make the movement of people and supplies difficult in the days immediately following the earthquake.

Table 97: Transportation System Damage for the State of Illinois

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage >50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	4,333	0	0	4,269
	Bridges	22,854	264	71	22,591
	Tunnels	0	0	0	0
Railways	Segments	8,441	0	0	8,441
	Bridges	1,030	6	0	1,024
	Tunnels	4	0	0	4
	Facilities	285	10	0	275
Bus	Facilities	119	1	0	119
Light Rail	Segments	900	0	0	899
	Bridges	38	0	0	38
	Facilities	401	401	401	0
Ferry	Facilities	11	11	11	0
Port	Facilities	514	20	0	497
Airport	Facilities	929	30	9	907
	Runways	705	0	0	705

Table 98: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage>50%)**	**Functionality >50% at Day 1**
40 Critical Counties	74	11	1	63
Remaining Counties	168	0	0	168
Total State	242	11	1	231

Table 99: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage>50%)**	**Functionality >50% at Day 1**
40 Critical Counties	2,221	461	8	1,246
Remaining Counties	7,168	0	0	7,168
Total State	9,389	461	8	8,414

Utility lifelines are significantly impacted by the NMSZ scenario event with hundreds of facilities moderately or completely damaged. Over 450 waste water facilities are moderately or more severely damaged while 8 incur complete damage. All facilities experiencing complete damage are located in the extreme southern counties in Illinois. Approximately 20% of all natural gas and electric power facilities in the critical counties incur at least moderate damage. Communication facilities are the most prominent utility

inventory type in Illinois and also report the most damage with 1,450 moderately or more severely damaged facilities.

Table 100: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
40 Critical Counties	388	79	4	309
Remaining Counties	945	0	0	945
Total State	1,333	79	4	1,254

Table 101: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
40 Critical Counties	109	3	0	106
Remaining Counties	166	0	0	166
Total State	275	3	0	272

Table 102: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage>50%)	Complete Damage (Damage>50%)	Functionality >50% at Day 1
40 Critical Counties	334	59	3	205
Remaining Counties	1,838	0	0	1,838
Total State	2,172	59	3	2,043

Table 103: Damage to Communication Facilities

Communication Facilities Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage>50%)	Complete Damage (Damage>50%)	Functionality >50% at Day 1
40 Critical Counties	7,464	1,450	66	6,577
Remaining Counties	27,369	0	0	27,369
Total State	34,833	1,450	66	33,946

Pipeline damage is estimated for local potable water, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not included in the HAZUS-MH MR2 default inventory, called local inventory in HAZUS-MH MR2, though regional oil pipelines are added to provide damage estimates for these major oil transmission lines. These oil pipelines are composed of major crude oil and refined product lines only. Regional and local natural gas networks

are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at roughly 5,500 and 5,400, respectively. Local natural gas lines, however; show the greatest break and leak rates per length of pipe at roughly 0.070 leaks/mile (1 leak every 14.3 miles) or 0.069 breaks/mile (roughly 1 break every 14.5 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of 4,666 leaks and 4,572 breaks over the combined length of 80,969 miles of natural gas pipeline.

Potable water service is cut off for over 70,700 residences the day after the scenario earthquake. This is reduced to roughly 43,000 residences within a week and no customers will be without service after three months. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program. This period of time without water prevents thousands of people from remaining in their homes in the weeks and months following the earthquake. Electric power service shows similar trends, with over 69,600 residential service outages the day after the earthquake, or nearly 1.5% of all state residences without power. Even a month after the earthquake nearly 6,700 residences are still without power. All electric power lines in Illinois are presumed to be above ground and less likely to incur damage from moderate ground shaking unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation.

Table 104: Pipeline Damage

Pipeline Damage			
System	Total Pipelines (mi)	No. Leaks	No. Breaks
Potable Water - Local	164,911	5,448	5,401
Waste Water - Local	98,946	4,340	4,272
Natural Gas - Local	65,964	4,640	4,566
Natural Gas - Regional	15,005	26	6
Oil - Regional	8,379	17	4

Table 105: Utility Service Interruptions for Critical Counties

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	4,591,779	70,781	56,532	43,091	26,770	0
Electric Power		69,641	48,139	24,340	6,678	83

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage

state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county. The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as discussed in footnote (4) and employed in the preceding damage tables for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Jackson County, Illinois – 194 waste water facilities
  - Estimation procedure according to footnote 4:
    - Summation of individual facilities after that facility is deemed 'damaged' or 'undamaged' based on 50% or greater damage likelihood requirement estimates **194 at least moderately damaged waste water facilities**
  - Estimation procedure according to topic damage tables in this appendix:
    - To determine the percentage of waste water facilities in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of facilities in that county
    - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **144 at least moderately damaged waste water facilities**

In the case of Jackson County, Illinois, the topic damage tables in this appendix provide a lower estimate of damage as opposed to the facility-by-facility damage summation detailed in footnote (4). Though not illustrated here, other counties in Illinois are estimated to incur greater damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged waste water facilities for the 40 critical counties in Illinois shows the following:

- Total number of at least moderately damaged waste water facilities according to the HAZUS-MH MR2 procedure for averaging damage at the county level
  - **642 at least moderately damaged waste water facilities**
- Total number of at least moderately damaged waste water facilities according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
  - **461 at least moderately damaged waste water facilities**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces less damage. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix for the NMSZ scenario in the State of Illinois.

The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Illinois. There tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage levels for a county.

Table 106: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Alexander						
Single Family	1	56	530	680	1,191	2458
Other Residential	0	2	17	40	764	823
Commercial	0	0	0	1	7	8
Industrial	0	0	0	0	0	0
Other	0	0	0	1	7	8
Bond						
Single Family	4,250	44	4	0	0	4298
Other Residential	1,095	117	15	0	0	1227
Commercial	23	1	0	0	0	24
Industrial	4	0	0	0	0	4
Other	6	0	0	0	0	6
Calhoun						
Single Family	1,804	19	1	0	0	1824
Other Residential	359	40	5	0	0	404
Commercial	19	0	0	0	0	19
Industrial	0	0	0	0	0	0
Other	5	0	0	0	0	5
Clark						
Single Family	5,158	54	4	0	0	5216
Other Residential	896	93	12	0	0	1001
Commercial	26	1	0	0	0	27
Industrial	17	0	0	0	0	17
Other	7	0	0	0	0	7
Clay						
Single Family	3,577	361	65	3	0	4006
Other Residential	718	268	134	3	0	1123
Commercial	25	6	3	0	0	34
Industrial	12	6	3	0	0	21
Other	12	1	0	0	0	13
Clinton						
Single Family	8,681	267	41	2	259	9250
Other Residential	1,419	298	118	3	102	1940
Commercial	58	8	3	0	3	72
Industrial	14	1	0	0	1	16
Other	11	1	0	0	0	12
Crawford						
Single Family	5,978	62	5	0	0	6045
Other Residential	746	78	10	0	0	834
Commercial	42	1	0	0	0	43
Industrial	5	0	0	0	0	5
Other	5	0	0	0	0	5

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Edwards						
Single Family	1,744	186	34	2	0	1966
Other Residential	388	174	91	2	0	655
Commercial	8	3	1	0	0	12
Industrial	14	3	2	0	0	19
Other	4	1	0	0	0	5
Effingham						
Single Family	9,289	97	8	0	0	9394
Other Residential	1,176	115	14	0	0	1305
Commercial	178	5	1	0	0	184
Industrial	60	2	0	0	0	62
Other	27	1	0	0	0	28
Fayette						
Single Family	5,541	58	5	0	0	5604
Other Residential	1,596	175	22	0	0	1793
Commercial	48	1	0	0	0	49
Industrial	3	0	0	0	0	3
Other	20	1	0	0	0	21
Franklin						
Single Family	9,670	1,634	302	17	123	11746
Other Residential	959	756	438	11	20	2184
Commercial	41	18	7	1	1	68
Industrial	6	3	2	0	0	11
Other	7	3	1	0	0	11
Gallatin						
Single Family	1,438	243	45	3	8	1737
Other Residential	294	263	156	4	2	719
Commercial	2	1	0	0	0	3
Industrial	0	0	0	0	0	0
Other	1	0	0	0	0	1
Greene						
Single Family	4,273	45	4	0	0	4322
Other Residential	676	69	9	0	0	754
Commercial	22	1	0	0	0	23
Industrial	2	0	0	0	0	2
Other	14	0	0	0	0	14
Hamilton						
Single Family	1,976	334	62	6	21	2399
Other Residential	290	257	152	5	6	710
Commercial	9	4	1	0	0	14
Industrial	1	0	0	0	0	1
Other	8	3	1	0	0	12

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Hardin						
Single Family	1,178	199	37	2	0	1416
Other Residential	205	178	105	3	0	491
Commercial	1	1	0	0	0	2
Industrial	0	0	0	0	0	0
Other	1	0	0	0	0	1
Jackson						
Single Family	8,652	1,967	349	20	975	11963
Other Residential	2,520	1,820	1,012	27	333	5712
Commercial	97	43	18	1	8	167
Industrial	4	2	1	0	0	7
Other	23	9	4	0	2	38
Jasper						
Single Family	2,901	30	2	0	0	2933
Other Residential	481	52	6	0	0	539
Commercial	10	0	0	0	0	10
Industrial	4	0	0	0	0	4
Other	5	0	0	0	0	5
Jefferson						
Single Family	8,275	1,398	259	18	42	9992
Other Residential	1,353	1,122	655	18	16	3164
Commercial	91	38	16	1	1	147
Industrial	15	7	3	0	0	25
Other	12	4	2	0	0	18
Jersey						
Single Family	6,203	65	5	0	0	6273
Other Residential	894	89	11	0	0	994
Commercial	34	1	0	0	0	35
Industrial	5	0	0	0	0	5
Other	16	0	0	0	0	16
Johnson						
Single Family	164	887	1,225	382	185	2843
Other Residential	8	74	396	576	324	1378
Commercial	0	0	3	6	7	16
Industrial	0	0	0	0	0	0
Other	0	0	1	3	3	7
Lawrence						
Single Family	3,421	578	107	5	201	4312
Other Residential	444	382	225	6	30	1087
Commercial	22	9	4	0	3	38
Industrial	4	2	1	0	1	8
Other	7	3	1	0	1	12

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Macoupin						
Single Family	14,351	150	12	0	0	14513
Other Residential	2,088	214	27	0	0	2329
Commercial	121	3	0	0	0	124
Industrial	10	0	0	0	0	10
Other	31	1	0	0	0	32
Madison						
Single Family	68,175	2,994	494	24	2,083	73770
Other Residential	5,945	1,014	420	10	322	7711
Commercial	595	61	21	1	15	693
Industrial	37	2	1	0	1	41
Other	77	7	2	0	1	87
Marion						
Single Family	10,367	738	129	6	0	11240
Other Residential	2,200	570	248	6	0	3024
Commercial	66	14	5	0	0	85
Industrial	18	2	1	0	0	21
Other	6	1	0	0	0	7
Massac						
Single Family	48	745	1,633	530	1,176	4132
Other Residential	1	16	175	418	774	1384
Commercial	0	0	4	9	18	31
Industrial	0	0	0	1	3	4
Other	0	0	1	2	4	7
Monroe						
Single Family	6,985	871	154	11	24	8045
Other Residential	335	153	82	2	2	574
Commercial	64	14	5	0	0	83
Industrial	2	0	0	0	0	2
Other	3	1	0	0	0	4
Montgomery						
Single Family	8,490	88	7	0	0	8585
Other Residential	1,014	104	13	0	0	1131
Commercial	70	2	0	0	0	72
Industrial	2	0	0	0	0	2
Other	10	0	0	0	0	10
Perry						
Single Family	4,884	825	153	10	59	5931
Other Residential	668	520	301	8	28	1525
Commercial	29	12	5	0	1	47
Industrial	4	2	1	0	0	7
Other	16	6	2	0	0	24

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Pope						
Single Family	712	375	212	50	10	1359
Other Residential	110	125	157	112	19	523
Commercial	0	1	2	1	0	4
Industrial	0	0	0	0	0	0
Other	0	0	1	1	0	2
Pulaski						
Single Family	1	71	649	468	616	1805
Other Residential	0	1	31	142	633	807
Commercial	0	0	0	2	11	13
Industrial	0	0	0	0	1	1
Other	0	0	0	1	9	10
Randolph						
Single Family	6,737	1,139	211	16	473	8576
Other Residential	891	736	430	12	89	2158
Commercial	42	18	7	1	6	74
Industrial	5	2	1	0	0	8
Other	19	7	3	0	1	30
Richland						
Single Family	4,992	52	4	0	0	5048
Other Residential	753	77	10	0	0	840
Commercial	40	1	0	0	0	41
Industrial	5	0	0	0	0	5
Other	4	0	0	0	0	4
Saint Clair						
Single Family	52,947	8,358	1,518	97	2,390	65310
Other Residential	5,979	2,869	1,501	42	410	10801
Commercial	381	139	56	4	14	594
Industrial	14	3	1	0	2	20
Other	76	24	9	1	3	113
Saline						
Single Family	6,524	1,102	204	14	30	7874
Other Residential	733	646	381	10	7	1777
Commercial	42	18	7	1	1	69
Industrial	1	1	0	0	0	2
Other	6	2	1	0	0	9
Union						
Single Family	19	390	1,780	1,410	1,137	4736
Other Residential	0	9	127	338	1,003	1477
Commercial	0	0	1	6	35	42
Industrial	0	0	0	0	1	1
Other	0	0	1	1	4	6

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Wabash						
Single Family	2,913	492	91	5	102	3603
Other Residential	366	301	176	4	12	859
Commercial	16	7	3	0	2	28
Industrial	0	0	0	0	0	0
Other	4	1	1	0	0	6
Washington						
Single Family	3,898	659	122	8	12	4699
Other Residential	271	246	146	4	2	669
Commercial	25	11	4	0	0	40
Industrial	1	1	0	0	0	2
Other	5	2	1	0	0	8
Wayne						
Single Family	4,568	157	25	1	0	4751
Other Residential	1,429	298	112	2	0	1841
Commercial	46	3	1	0	0	50
Industrial	9	1	0	0	0	10
Other	11	1	0	0	0	12
White						
Single Family	3,546	854	152	12	32	4596
Other Residential	487	425	251	7	7	1177
Commercial	19	9	4	0	0	32
Industrial	1	1	0	0	0	2
Other	3	1	0	0	0	4
Williamson						
Single Family	12,946	2,809	502	27	437	16721
Other Residential	1,789	1,304	727	19	182	4021
Commercial	115	51	21	2	5	194
Industrial	6	3	2	0	0	11
Other	16	6	3	0	1	26

Table 107: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Alexander	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bond	189	182	96.40	182	96.50	188	99.30	189	99.90	189	99.90
Calhoun	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clark	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Clay	22	10	47.70	11	48.30	16	73.60	21	97.60	22	98.80
Clinton	197	142	72.05	143	72.40	170	86.45	195	98.75	196	99.35
Crawford	93	90	96.40	90	96.50	92	99.30	93	99.90	93	99.90
Edwards	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Effingham	146	141	96.40	141	96.50	145	99.30	146	99.90	146	99.90
Fayette	48	46	96.40	46	96.50	48	99.30	48	99.90	48	99.90
Franklin	158	75	47.20	76	47.80	115	72.90	153	96.60	155	97.80
Gallatin	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Greene	73	70	96.40	70	96.50	72	99.30	73	99.90	73	99.90
Hamilton	101	48	47.20	48	47.80	74	72.90	98	96.60	99	97.80
Hardin	48	17	35.80	17	36.20	26	55.20	35	73.20	36	74.10
Jackson	209	94	45.00	95	45.50	146	69.70	194	92.70	196	93.80
Jasper	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jefferson	207	98	47.45	99	48.05	152	73.25	201	97.10	203	98.30
Jersey	67	65	96.40	65	96.50	67	99.30	67	99.90	67	99.90
Johnson	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lawrence	58	28	47.70	28	48.30	43	73.60	57	97.60	57	98.80
Macoupin	82	79	96.40	79	96.50	81	99.30	82	99.90	82	99.90
Madison	1,294	1,122	86.70	1,124	86.87	1,208	93.37	1,266	97.87	1,269	98.07
Marion	322	232	72.05	233	72.40	278	86.45	318	98.75	320	99.35
Massac	57	0	0.00	0	0.00	0	0.00	1	2.00	8	13.80
Monroe	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Montgomery	197	190	96.40	190	96.50	196	99.30	197	99.90	197	99.90
Perry	125	59	47.45	60	48.05	92	73.25	121	97.10	123	98.30
Pope	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pulaski	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Randolph	542	257	47.45	260	48.05	397	73.25	526	97.10	533	98.30
Richland	122	118	96.40	118	96.50	121	99.30	122	99.90	122	99.90
Saint Clair	1,153	571	49.54	577	50.04	826	71.68	1,061	91.98	1,072	92.98
Saline	131	62	47.45	63	48.05	96	73.25	127	97.10	129	98.30
Union	508	0	0.00	0	0.00	1	0.20	68	13.40	218	42.90
Wabash	56	27	47.70	27	48.30	41	73.60	55	97.60	55	98.80
Washington	61	29	47.70	29	48.30	45	73.60	60	97.60	60	98.80
Wayne	185	178	96.40	179	96.50	184	99.30	185	99.90	185	99.90
White	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Williamson	363	172	47.30	174	47.90	266	73.30	354	97.60	359	98.80

* Note: Discrepancies between the number of hospital beds and the percentage of beds may occur due to rounding.

Table 108: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Alexander	112	25.25	36.96	46.58	73.81	95.33
Bond	97	98.98	99.78	99.84	99.90	99.90
Calhoun	41	99.80	99.90	99.90	99.90	99.90
Clark	156	99.80	99.90	99.90	99.90	99.90
Clay	111	93.62	98.96	99.43	99.90	99.90
Clinton	254	93.17	98.87	99.37	99.87	99.89
Crawford	174	99.80	99.90	99.90	99.90	99.90
Edwards	77	93.20	98.90	99.40	99.90	99.90
Effingham	237	99.80	99.90	99.90	99.90	99.90
Fayette	168	99.80	99.90	99.90	99.90	99.90
Franklin	194	74.10	91.38	94.15	99.02	99.80
Gallatin	59	77.02	92.29	94.39	98.18	99.64
Greene	95	99.80	99.90	99.90	99.90	99.90
Hamilton	91	78.40	94.00	96.10	99.50	99.90
Hardin	30	77.83	93.29	95.39	98.95	99.79
Jackson	338	49.06	70.46	77.57	93.32	98.75
Jasper	97	99.80	99.90	99.90	99.90	99.90
Jefferson	237	85.28	96.27	97.63	99.69	99.90
Jersey	78	99.80	99.90	99.90	99.90	99.90
Johnson	125	35.90	55.36	65.39	89.22	98.01
Lawrence	109	93.14	98.84	99.34	99.85	99.89
Macoupin	285	99.80	99.90	99.90	99.90	99.90
Madison	781	95.65	99.14	99.45	99.77	99.87
Marion	239	93.20	98.90	99.40	99.90	99.90
Massac	128	39.88	60.05	68.70	89.12	98.03
Monroe	129	88.08	97.04	98.08	99.59	99.87
Montgomery	240	99.80	99.90	99.90	99.90	99.90
Perry	155	78.34	93.93	96.03	99.45	99.89
Pope	105	64.84	85.76	90.03	98.05	99.60
Pulaski	85	26.00	38.62	48.64	76.06	95.72
Randolph	248	78.90	93.63	95.61	98.96	99.79
Richland	118	93.20	98.90	99.40	99.90	99.90
Saint Clair	811	89.50	97.54	98.41	99.64	99.87
Saline	167	77.20	93.27	95.58	99.41	99.88
Union	177	23.81	34.65	44.87	73.65	95.27
Wabash	104	93.15	98.85	99.35	99.86	99.89
Washington	161	89.80	97.77	98.64	99.81	99.90
Wayne	161	93.20	98.90	99.40	99.90	99.90
White	187	78.24	93.80	95.90	99.35	99.87
Williamson	303	53.12	75.23	81.85	95.84	99.18

Table 109: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Alexander	2	0.00
Bond	3	94.10
Calhoun	2	94.10
Clark	5	94.10
Clay	2	73.00
Clinton	8	84.83
Crawford	5	94.10
Edwards	3	65.97
Effingham	5	94.10
Fayette	6	94.10
Franklin	7	71.53
Gallatin	6	68.82
Greene	5	94.10
Hamilton	1	71.30
Hardin	3	66.07
Jackson	6	66.00
Jasper	2	94.10
Jefferson	2	71.30
Jersey	4	94.10
Johnson	1	0.00
Lawrence	5	51.90
Macoupin	14	94.10
Madison	39	80.69
Marion	6	95.80
Massac	8	0.00
Monroe	6	50.13
Montgomery	11	94.10
Perry	7	51.76
Pope	4	39.13
Pulaski	6	0.00
Randolph	9	50.18
Richland	2	94.10
Saint Clair	36	58.30
Saline	4	56.18
Union	3	0.00
Wabash	2	51.90
Washington	11	52.31
Wayne	4	84.73
White	7	46.71
Williamson	5	61.26

Table 110: School Functionality

Counties	Count	Functionality at Day 1 (%)
Alexander	15	0.00
Bond	8	94.10
Calhoun	7	94.10
Clark	9	94.10
Clay	11	59.57
Clinton	26	80.03
Crawford	12	94.10
Edwards	3	65.97
Effingham	25	94.10
Fayette	13	94.10
Franklin	28	71.64
Gallatin	1	71.30
Greene	9	94.10
Hamilton	6	71.30
Hardin	5	68.48
Jackson	80	67.40
Jasper	7	94.10
Jefferson	19	59.89
Jersey	11	94.10
Johnson	8	0.20
Lawrence	8	51.05
Macoupin	32	94.10
Madison	320	87.98
Marion	30	79.18
Massac	33	0.00
Monroe	25	53.94
Montgomery	20	94.10
Perry	15	51.77
Pope	31	42.01
Pulaski	9	0.00
Randolph	22	49.85
Richland	7	94.10
Saint Clair	212	58.26
Saline	17	46.42
Union	12	0.00
Wabash	8	51.90
Washington	22	46.63
Wayne	13	81.02
White	12	46.70
Williamson	16	67.06

Table 111: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Alexander	7	0.00
Bond	8	94.10
Calhoun	5	94.10
Clark	4	94.10
Clay	5	68.78
Clinton	6	84.68
Crawford	5	94.10
Edwards	4	73.00
Effingham	11	94.10
Fayette	6	94.10
Franklin	14	71.69
Gallatin	6	62.78
Greene	8	94.10
Hamilton	3	71.30
Hardin	3	66.07
Jackson	12	67.23
Jasper	3	94.10
Jefferson	12	61.30
Jersey	4	94.10
Johnson	6	0.13
Lawrence	5	50.54
Macoupin	16	94.10
Madison	64	78.96
Marion	4	81.63
Massac	7	0.00
Monroe	7	62.74
Montgomery	12	94.10
Perry	7	51.83
Pope	4	26.35
Pulaski	8	0.00
Randolph	6	51.57
Richland	5	94.10
Saint Clair	43	55.92
Saline	4	30.23
Union	8	0.00
Wabash	5	51.90
Washington	7	36.56
Wayne	6	82.03
White	6	46.73
Williamson	10	57.59

Table 112: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Alexander	3,808	94.40	82.80	59.60	21.90	0.10
Bond	6,155	0	0	0	0	0
Calhoun	2,046	0	0	0	0	0
Clark	6,971	0	0	0	0	0
Clay	5,839	0	0	0	0	0
Clinton	12,754	0	0	0	0	0
Crawford	7,842	0	0	0	0	0
Edwards	2,905	0	0	0	0	0
Effingham	13,001	0	0	0	0	0
Fayette	8,146	0	0	0	0	0
Franklin	16,408	29.20	14.90	4.10	0.50	0
Gallatin	2,726	0	0	0	0	0
Greene	5,757	0	0	0	0	0
Hamilton	3,462	0	0	0	0	0
Hardin	1,987	0	0	0	0	0
Jackson	24,215	83.10	55.50	25.10	5.70	0.10
Jasper	3,930	0	0	0	0	0
Jefferson	15,374	0	0	0	0	0
Jersey	8,096	0	0	0	0	0
Johnson	4,183	89.70	67.80	35.50	8.20	0.10
Lawrence	6,309	0	0	0	0	0
Macoupin	19,253	0	0	0	0	0
Madison	101,953	0	0	0	0	0
Marion	16,619	0	0	0	0	0
Massac	6,261	86.90	63.70	35.40	11.30	0.10
Monroe	10,275	0	0	0	0	0
Montgomery	11,507	0	0	0	0	0
Perry	8,504	0	0	0	0	0
Pope	1,769	70.40	35.80	9.80	1.20	0.10
Pulaski	2,893	94.30	82.00	57.50	20.30	0.10
Randolph	12,084	0	0	0	0	0
Richland	6,660	0	0	0	0	0
Saint Clair	96,810	0	0	0	0	0
Saline	10,992	7.60	3.90	1.10	0.10	0
Union	7,290	95.20	85.70	63.40	23.20	0.10
Wabash	5,192	0	0	0	0	0
Washington	5,848	0	0	0	0	0
Wayne	7,143	0	0	0	0	0
White	6,534	0	0	0	0	0
Williamson	25,358	79.70	49.70	19.90	4.00	0.10

Table 113: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Alexander	N/A	N/A	N/A	N/A	N/A	N/A
Bond	1	96.63	3.21	0.15	0.00	0.00
Calhoun	3	96.63	3.21	0.15	0.00	0.00
Clark	3	96.63	3.21	0.15	0.00	0.00
Clay	1	50.00	37.59	11.35	0.98	0.06
Clinton	2	50.00	37.59	11.35	0.98	0.06
Crawford	N/A	N/A	N/A	N/A	N/A	N/A
Edwards	1	50.00	37.59	11.35	0.98	0.06
Effingham	3	96.63	3.21	0.15	0.00	0.00
Fayette	2	96.63	3.21	0.15	0.00	0.00
Franklin	1	19.73	42.20	30.82	6.56	0.67
Gallatin	3	19.27	41.22	30.11	6.41	2.98
Greene	4	96.63	3.21	0.15	0.00	0.00
Hamilton	N/A	N/A	N/A	N/A	N/A	N/A
Hardin	N/A	N/A	N/A	N/A	N/A	N/A
Jackson	2	2.45	17.06	38.32	26.39	15.76
Jasper	1	96.63	3.21	0.15	0.00	0.00
Jefferson	N/A	N/A	N/A	N/A	N/A	N/A
Jersey	N/A	N/A	N/A	N/A	N/A	N/A
Johnson	3	0.74	8.99	33.30	36.82	20.13
Lawrence	2	49.81	37.45	11.31	0.98	0.45
Macoupin	4	96.63	3.21	0.15	0.00	0.00
Madison	8	61.46	28.85	8.51	0.73	0.43
Marion	2	50.00	37.59	11.35	0.98	0.06
Massac	N/A	N/A	N/A	N/A	N/A	N/A
Monroe	1	18.35	39.26	28.68	6.10	7.59
Montgomery	4	96.63	3.21	0.15	0.00	0.00
Perry	N/A	N/A	N/A	N/A	N/A	N/A
Pope	N/A	N/A	N/A	N/A	N/A	N/A
Pulaski	1	0.16	3.24	19.73	36.47	40.38
Randolph	4	19.39	41.47	30.29	6.45	2.40
Richland	N/A	N/A	N/A	N/A	N/A	N/A
Saint Clair	6	39.78	39.03	17.81	2.84	0.52
Saline	N/A	N/A	N/A	N/A	N/A	N/A
Union	2	0.03	0.69	8.94	37.31	53.02
Wabash	1	50.00	37.59	11.35	0.98	0.06
Washington	2	50.00	37.59	11.35	0.98	0.06
Wayne	3	50.00	37.59	11.35	0.98	0.06
White	1	19.73	42.20	30.82	6.56	0.67
Williamson	3	1.74	13.81	37.89	34.13	12.40

Table 114: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Alexander	3,808	99.7	99.7	99.5	83.6	0
Bond	6,155	0	0	0	0	0
Calhoun	2,046	0	0	0	0	0
Clark	6,971	0	0	0	0	0
Clay	5,839	0	0	0	0	0
Clinton	12,754	11	0.8	0	0	0
Crawford	7,842	0	0	0	0	0
Edwards	2,905	0	0	0	0	0
Effingham	13,001	0	0	0	0	0
Fayette	8,146	0	0	0	0	0
Franklin	16,408	0	0	0	0	0
Gallatin	2,726	0	0	0	0	0
Greene	5,757	0	0	0	0	0
Hamilton	3,462	0	0	0	0	0
Hardin	1,987	0	0	0	0	0
Jackson	24,215	96.9	96.6	95.8	82.5	0
Jasper	3,930	0	0	0	0	0
Jefferson	15,374	0	0	0	0	0
Jersey	8,096	0	0	0	0	0
Johnson	4,183	4.6	0	0	0	0
Lawrence	6,309	0	0	0	0	0
Macoupin	19,253	0	0	0	0	0
Madison	101,953	2.9	0.3	0	0	0
Marion	16,619	0	0	0	0	0
Massac	6,261	99.5	99.4	99	57.6	0
Monroe	10,275	0	0	0	0	0
Montgomery	11,507	0	0	0	0	0
Perry	8,504	0	0	0	0	0
Pope	1,769	0	0	0	0	0
Pulaski	2,893	99.4	99.3	98.8	0	0
Randolph	12,084	31.2	16.3	0	0	0
Richland	6,660	0	0	0	0	0
Saint Clair	96,810	7.8	2.7	0	0	0
Saline	10,992	0	0	0	0	0
Union	7,290	85.3	80.9	66	0	0
Wabash	5,192	0	0	0	0	0
Washington	5,848	0	0	0	0	0
Wayne	7,143	0	0	0	0	0
White	6,534	0	0	0	0	0
Williamson	25,358	48.6	36.9	8.8	0	0

Table 115: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Alexander	22	0.12	2.39	16.28	37.72	43.46
Bond	24	81.09	14.67	3.88	0.33	0.02
Calhoun	5	96.63	3.21	0.15	0.00	0.00
Clark	34	96.63	3.21	0.15	0.00	0.00
Clay	20	50.00	37.59	11.35	0.98	0.06
Clinton	77	49.96	37.56	11.34	0.98	0.13
Crawford	31	96.63	3.21	0.15	0.00	0.00
Edwards	16	50.00	37.59	11.35	0.98	0.06
Effingham	67	96.63	3.21	0.15	0.00	0.00
Fayette	29	96.63	3.21	0.15	0.00	0.00
Franklin	59	15.57	38.71	34.52	9.63	1.55
Gallatin	67	19.58	41.89	30.59	6.51	1.40
Greene	30	96.63	3.21	0.15	0.00	0.00
Hamilton	7	19.73	42.20	30.82	6.56	0.67
Hardin	27	19.42	41.55	30.34	6.46	2.21
Jackson	194	4.46	21.53	38.52	24.77	10.70
Jasper	20	96.63	3.21	0.15	0.00	0.00
Jefferson	58	28.08	40.93	25.45	5.02	0.50
Jersey	27	96.63	3.21	0.15	0.00	0.00
Johnson	23	0.65	8.31	32.94	39.67	18.41
Lawrence	35	49.83	37.47	11.31	0.98	0.39
Macoupin	79	96.63	3.21	0.15	0.00	0.00
Madison	273	74.83	19.13	5.34	0.45	0.23
Marion	67	50.00	37.59	11.35	0.98	0.06
Massac	31	1.14	11.00	34.84	34.60	18.40
Monroe	43	33.67	39.82	21.60	3.93	0.96
Montgomery	87	96.63	3.21	0.15	0.00	0.00
Perry	73	19.73	42.20	30.82	6.56	0.68
Pope	14	8.63	33.09	41.05	14.92	2.29
Pulaski	26	0.15	3.11	19.94	39.66	37.13
Randolph	70	21.48	40.99	28.79	6.02	2.70
Richland	18	50.00	37.59	11.35	0.98	0.06
Saint Clair	243	42.48	38.55	16.01	2.32	0.61
Saline	84	19.73	42.20	30.82	6.56	0.68
Union	25	0.05	1.40	12.99	39.83	45.71
Wabash	22	49.95	37.55	11.34	0.98	0.17
Washington	43	45.07	38.34	14.52	1.89	0.16
Wayne	24	50.00	37.59	11.35	0.98	0.06
White	23	19.67	42.07	30.73	6.54	0.97
Williamson	104	4.91	23.32	40.15	24.13	7.47

Table 116: Highway Bridge Damage

Counties	# of Bridges	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Alexander	91	13.75	6.74	7.48	16.78	55.22
Bond	150	98.53	0.92	0.27	0.23	0.03
Calhoun	58	99.18	0.46	0.21	0.12	0.02
Clark	180	99.28	0.47	0.14	0.09	0.01
Clay	152	98.72	0.83	0.26	0.15	0.02
Clinton	175	97.27	0.79	0.25	1.51	0.16
Crawford	170	99.31	0.45	0.13	0.08	0.01
Edwards	80	98.75	0.82	0.25	0.14	0.02
Effingham	217	98.62	0.90	0.28	0.16	0.02
Fayette	320	98.87	0.69	0.25	0.15	0.02
Franklin	238	95.63	0.81	0.17	0.53	2.84
Gallatin	71	88.63	1.09	0.21	0.16	9.88
Greene	140	98.25	1.11	0.39	0.21	0.03
Hamilton	167	98.54	0.95	0.18	0.24	0.05
Hardin	44	96.01	2.08	0.42	0.30	1.17
Jackson	177	82.61	4.22	0.28	0.59	12.28
Jasper	151	98.25	1.15	0.37	0.19	0.02
Jefferson	213	97.49	1.12	0.24	0.27	0.86
Jersey	90	97.35	1.65	0.62	0.32	0.04
Johnson	103	68.28	8.69	5.32	9.54	8.15
Lawrence	148	92.09	1.74	0.41	4.38	1.36
Macoupin	206	98.21	1.19	0.37	0.19	0.02
Madison	396	94.79	1.10	0.36	3.18	0.54
Marion	247	98.30	1.14	0.34	0.18	0.02
Massac	118	63.62	6.39	4.34	7.87	17.75
Monroe	102	87.44	3.78	0.28	3.03	5.45
Montgomery	212	97.90	1.31	0.49	0.26	0.04
Perry	124	91.66	1.60	0.36	0.43	5.93
Pope	71	85.89	3.99	2.03	2.25	5.82
Pulaski	93	34.52	8.45	7.53	14.99	34.49
Randolph	136	87.70	1.73	0.36	0.58	9.61
Richland	131	98.68	0.89	0.26	0.14	0.02
Saint Clair	383	92.11	1.25	0.31	4.83	1.48
Saline	164	97.65	1.54	0.34	0.41	0.05
Union	178	47.38	10.27	8.12	14.32	19.89
Wabash	76	97.48	0.70	0.32	1.42	0.06
Washington	202	98.34	0.83	0.19	0.53	0.10
Wayne	234	98.42	1.04	0.32	0.18	0.02
White	197	92.45	3.45	0.31	0.31	3.45
Williamson	149	90.53	2.47	0.24	0.85	5.88

Table 117: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Alexander	91	22.60	26.54	29.64	32.22	44.26
Bond	150	99.25	99.56	99.66	99.69	99.80
Calhoun	58	99.53	99.69	99.78	99.79	99.85
Clark	180	99.62	99.77	99.83	99.84	99.87
Clay	152	99.37	99.65	99.75	99.77	99.84
Clinton	175	97.95	98.22	98.33	98.47	99.22
Crawford	170	99.63	99.78	99.83	99.84	99.87
Edwards	80	99.39	99.66	99.76	99.78	99.84
Effingham	217	99.33	99.63	99.74	99.76	99.84
Fayette	320	99.41	99.65	99.75	99.77	99.84
Franklin	238	96.31	96.55	96.63	96.73	97.18
Gallatin	71	89.66	89.99	90.10	90.26	91.00
Greene	140	99.15	99.53	99.68	99.71	99.81
Hamilton	167	99.27	99.56	99.63	99.67	99.78
Hardin	44	97.67	98.31	98.48	98.53	98.76
Jackson	177	86.05	87.19	87.34	87.56	88.69
Jasper	151	99.17	99.56	99.70	99.73	99.82
Jefferson	213	98.37	98.72	98.82	98.87	99.06
Jersey	90	98.72	99.31	99.55	99.60	99.75
Johnson	103	76.78	80.54	82.66	83.87	89.16
Lawrence	148	93.66	94.21	94.43	94.84	97.11
Macoupin	206	99.16	99.56	99.70	99.73	99.82
Madison	396	95.80	96.20	96.37	96.67	98.28
Marion	247	99.20	99.58	99.71	99.74	99.82
Massac	118	70.26	73.12	74.89	76.03	81.15
Monroe	102	90.52	91.56	91.72	92.07	93.94
Montgomery	212	98.97	99.43	99.62	99.66	99.79
Perry	124	93.04	93.54	93.70	93.83	94.44
Pope	71	89.60	91.20	92.01	92.38	93.88
Pulaski	93	44.20	48.56	51.62	53.77	63.54
Randolph	136	89.25	89.80	89.97	90.16	91.09
Richland	131	99.36	99.66	99.76	99.78	99.84
Saint Clair	383	93.30	93.72	93.89	94.35	96.85
Saline	164	98.87	99.34	99.48	99.53	99.73
Union	178	58.29	63.27	66.51	68.45	76.89
Wabash	76	98.09	98.36	98.49	98.63	99.34
Washington	202	98.98	99.24	99.32	99.37	99.63
Wayne	234	99.25	99.59	99.72	99.74	99.83
White	197	95.14	96.11	96.23	96.33	96.71
Williamson	149	92.56	93.25	93.36	93.53	94.34

Table 118: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Alexander	539	1,457	949
Bond	979	5	1
Calhoun	524	3	1
Clark	1,305	7	2
Clay	1,300	7	2
Clinton	1,384	33	104
Crawford	1,303	7	2
Edwards	587	3	1
Effingham	1,444	8	2
Fayette	2,004	11	3
Franklin	1,332	11	17
Gallatin	656	4	4
Greene	1,088	6	1
Hamilton	1,026	8	12
Hardin	372	2	1
Jackson	1,677	394	1,348
Jasper	1,291	7	2
Jefferson	1,685	11	11
Jersey	873	5	1
Johnson	725	211	53
Lawrence	1,162	12	22
Macoupin	2,193	12	3
Madison	2,998	46	121
Marion	1,743	10	2
Massac	588	454	861
Monroe	827	6	6
Montgomery	1,813	10	2
Perry	1,062	9	16
Pope	546	30	7
Pulaski	463	685	681
Randolph	1,381	50	172
Richland	1,060	6	1
Saint Clair	2,949	57	167
Saline	1,025	7	5
Union	912	1,122	384
Wabash	603	5	7
Washington	1,262	8	7
Wayne	1,893	10	3
White	1,461	10	12
Williamson	1,426	107	248

Table 119: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Alexander	323	1,153	751
Bond	587	4	1
Calhoun	315	2	1
Clark	783	6	1
Clay	780	6	1
Clinton	830	26	82
Crawford	782	6	1
Edwards	352	3	1
Effingham	867	6	2
Fayette	1,202	9	2
Franklin	799	9	13
Gallatin	394	4	4
Greene	653	5	1
Hamilton	616	6	9
Hardin	223	2	0
Jackson	1,006	312	1,066
Jasper	774	6	1
Jefferson	1,011	9	9
Jersey	524	4	1
Johnson	435	167	42
Lawrence	697	9	18
Macoupin	1,316	9	2
Madison	1,799	36	96
Marion	1,046	8	2
Massac	353	359	681
Monroe	496	4	5
Montgomery	1,088	8	2
Perry	637	7	13
Pope	328	24	6
Pulaski	278	542	538
Randolph	829	40	136
Richland	636	5	1
Saint Clair	1,769	45	132
Saline	615	5	4
Union	547	888	303
Wabash	362	4	6
Washington	757	6	5
Wayne	1,136	8	2
White	877	8	9
Williamson	855	85	196

Indiana – New Madrid Seismic Zone Scenario

This earthquake impact assessment includes all 92 counties in the State of Indiana. Indiana is approximately 36,100 square miles and is bordered by Michigan to the north, Kentucky to the south, Ohio to the east, and Illinois to the west. For the purposes of this analysis, 11 critical counties have been identified in the southwestern portion of the state where shaking is anticipated to be most intense. These 11 counties are the focus of much of the damage assessment included within this document. The critical counties are listed below:

- Daviess
- Dubois
- Gibson
- Greene
- Knox
- Pike
- Posey
- Spencer
- Sullivan
- Vanderburgh
- Warrick

Please note critical counties for Indiana are the same for both scenarios. Both hazards are located in the southwestern portion of the state and thus the same set of critical counties is sufficient for both Indiana scenarios.

The NMSZ scenario for the State of Indiana consists of a magnitude 7.7 (M_w7.7) earthquake along one segment of the New Madrid Fault. The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS) for the middle fault in the proposed New Madrid Seismic Zone. Each fault line is presumed to consist of three fault segments; northeastern, central, and southwestern. This scenario, the worst case event for Indiana, employs an event in the northeast segment of the eastern fault. For more information on the ground motion used in this scenario please reference Appendix I.

The M_w7.7 event in the NMSZ does not generate catastrophic damage as it does in other central U.S. states. Shaking is less intense even in southwestern Indiana which is closest to the fault. Complete damage to buildings is extremely limited, though moderate damage is likely in southwestern counties such as Posey, Gibson and Vanderburgh. Most damaged structures are residential and either single family homes or other residential buildings which are often multi-resident buildings. Approximately 93% of all damage occurs in these two types of residential structures. The critical counties in southwestern Indiana experience just over half of all building damage. This indicates that damage occurs in locations with minor shaking though soft soils in outlying areas may contribute to the extent of moderate damage outside the 11 critical counties.

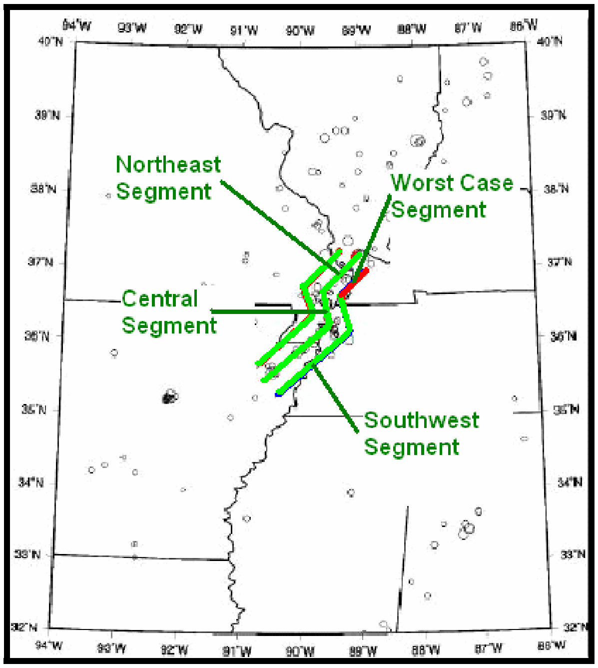

Figure 5: Location of Fault Rupture for Indiana NMSZ Scenario

Table 120: Damage by General Occupancy Type for the State of Indiana

General Occupancy Type Damage (State level)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,675,434	2,814	2
Other Residential	229,169	3,189	0
Commercial	19,034	154	0
Industrial	4,317	37	0
Other	4,102	266	0
Total	1,932,056	6,460	2

Table 121: Damage by General Occupancy Type for the 11 Critical Counties

General Occupancy Type Damage (11 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	133,792	1,652	2
Other Residential	21,966	1,386	0
Commercial	1,410	100	0
Industrial	279	21	0
Other	1,967	261	0
Total	159,414	3,420	2

Table 122: Building Damage by Building Type for the State of Indiana

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,388,618	7,908	150	0	0
Steel	8,288	463	191	13	0
Concrete	2,618	126	39	1	0
Precast	2,862	158	90	7	0
Reinforced Masonry	1,737	35	14	1	0
Unreinforced Masonry	337,716	18,051	2,823	109	2
Mobile Home	140,340	16,674	2,994	28	0
Total	1,882,179	43,415	6,301	159	2

Unlike the previous state scenarios, the NMSZ event for Indiana generates relatively little damage to wood frame structures. At the low levels of shaking experienced in southern Indiana the relatively flexibly nature of wood frame construction lets these buildings move with the imposed motion and bend without breaking. More brittle structures, such as unreinforced masonry (URM) buildings are more likely to crack at mortar joints and through the bricks themselves even during minor to moderate shaking. Mobile homes are likely to be shaken partially off of their foundations leading which defines moderate damage for this building type. Over 90% of all moderate and more severe damage is experienced by these URMs and mobile homes, making them some of the most vulnerable construction types in the State of Indiana.

Table 123: Essential Facilities Damage & Functionality for Indiana[5]

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	175	0	0	166
Schools	2,686	0	0	2,630
EOCs	51	0	0	50
Police Stations	474	0	0	468
Fire Stations	1,210	0	0	1,192

[5] For Tables 123-133 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Table 124: Essential Facilities Damage & Functionality for the Critical Counties

Essential Facilities Damage & Functionality				
Essential Facility Type	Total No. Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
Hospitals	16	0	0	16
Schools	223	0	0	223
EOCs	6	0	0	6
Police Stations	44	0	0	44
Fire Stations	146	0	0	146

Damage to essential facilities and transportation lifelines is minimal even in the 11 critical counties. No facilities are estimated in incur moderate or more severe damage. Impacts to infrastructure functionality are limited as well. It is likely that emergency services will not be greatly impacted and will be able to travel through the more affected areas of southern Indiana without many complications since all airports and bridges are estimated to remain operational in the days immediately after the earthquake.

Table 125: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	2,220	0	0	2,220
Remaining Counties	14,285	0	0	14,285
Total State	16,505	0	0	16,505

Table 126: Airport Damage Assessments

Airport Damage Assessments				
	Total No. Of Airports	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	49	0	0	49
Remaining Counties	447	0	0	447
Total State	496	0	0	496

Table 127: Transportation System Damage for the State of Indiana

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage >50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	2,844	0	0	2,844
	Bridges	16,505	0	0	16,505
	Tunnels	0	0	0	0
Railways	Segments	4,988	0	0	4,988
	Bridges	92	0	0	92
	Tunnels	8	0	0	8
	Facilities	91	0	0	91
Bus	Facilities	46	0	0	46
Light Rail	Segments	15	0	0	15
	Bridges	0	0	0	0
	Facilities	13	13	13	0
Ferry	Facilities	0	0	0	0
Port	Facilities	91	0	0	91
Airport	Facilities	496	0	0	496
	Runways	538	0	0	538

Utility lifelines show limited damage in the 11 critical counties and throughout the State of Indiana. Low levels of shaking are not likely to generate moderate damage to facilities and impair functionality immediately after the earthquake. Very minor damage to some of the facilities in the critical counties is more likely though this would amount to minor cracking of structural components and other forms of damage that do not reduce the operational capabilities of these lifelines.

Table 128: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
11 Critical Counties	16	0	0	16
Remaining Counties	80	0	0	80
Total State	96	0	0	96

Table 129: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
11 Critical Counties	52	0	0	52
Remaining Counties	394	0	0	394
Total State	446	0	0	446

Table 130: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
11 Critical Counties	7	0	0	7
Remaining Counties	22	0	0	22
Total State	29	0	0	29

Table 131: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
11 Critical Counties	35	0	0	35
Remaining Counties	135	0	0	135
Total State	170	0	0	170

Table 132: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	97	0	0	97
Remaining Counties	695	0	0	695
Total State	792	0	0	792

Table 133: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	2,490	0	0	2,490
Remaining Counties	19,189	0	0	19,189
Total State	21,679	0	0	21,679

Pipeline damage is estimated for local potable water, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not present in the default inventory, or local inventory in HAZUS-MH MR2, though regional, or major transmission, oil pipelines are added from HSIP 2007 data to provide estimates for these major oil transmission lines. These oil pipelines are comprised of major crude oil and refined product lines only. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at 728 and 753, respectively. Local natural gas lines, however, show the greatest break and leak rates per length of pipe

at roughly 0.014 leaks/mile and breaks/mile (roughly 1 leak/break every 70 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of 650 leaks and 652 breaks over the combined length of 54,746 miles of natural gas pipeline.

Potable water service is cut off to over 44,100 residences the day after the scenario earthquake. This is reduced to 11,100 residences within a week, and all service is restored after one month. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. This period of time without water prevents people from remaining in their homes in the weeks immediately following the earthquake. Electric power lines are presumed to be above ground and less likely to incur damage from moderate ground shaking, unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation. As a result of the low level of shaking, electric power service is not likely to be interrupted for residences in Indiana, even in the first few days following the earthquake.

Table 134: Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	111,394	753	728
Waste Water - Local	66,836	596	576
Natural Gas - Regional	10,188	13	36
Natural Gas - Local	44,558	637	616
Oil - Regional	4,625	17	60

Table 135: Utility Service Interruptions in Critical Counties

Utility Service Interruptions Number of Households without Service						
	No. Households (Critical Counties)	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	188,251	44,115	34,798	11,075	0	0
Electric Power		0	0	0	0	0

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage level available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county. The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as discussed in footnote (5) and employed in the preceding tables for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they

generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Gibson County, Indiana – 293 highway bridges
    - Estimation procedure according to footnote 5:
        - Summation of individual bridges after that bridge is deemed ‘damaged’ or ‘undamaged’ based on 50% or greater damage likelihood requirement estimates **0 at least moderately damaged highway bridges**
    - Estimation procedure according to topic damage tables in this appendix:
        - To determine the percentage of highway bridges in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of bridges in that county
        - Using these damage state probabilities averaged over all the bridges in the county provides an estimate of **18 at least moderately damaged highway bridges**

Comparing damage estimates for these two methods clearly shows that the averaging procedure in the topic damage tables produces more damage. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix.

The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Indiana. These tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage level for a county.

Table 136: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Daviess						
Single Family	7,768	289	43	2	0	8,102
Other Residential	1,040	229	95	2	0	1,366
Commercial	73	4	1	0	0	78
Industrial	9	2	1	0	0	12
Other	16	3	1	0	0	20
Dubois						
Single Family	10,692	101	8	0	0	10,801
Other Residential	1,311	100	12	0	0	1,423
Commercial	127	3	0	0	0	130
Industrial	89	2	0	0	0	91
Other	17	0	0	0	0	17
Gibson						
Single Family	9,132	303	45	2	0	9,482
Other Residential	1,506	264	89	2	0	1,861
Commercial	60	3	1	0	0	64
Industrial	8	0	0	0	0	8
Other	20	1	0	0	0	21
Greene						
Single Family	9,007	85	7	0	0	9,099
Other Residential	3,113	320	40	0	0	3,473
Commercial	76	2	0	0	0	78
Industrial	9	0	0	0	0	9
Other	19	1	0	0	0	20
Knox						
Single Family	10,946	103	8	0	0	11,057
Other Residential	1,567	117	14	0	0	1,698
Commercial	111	3	0	0	0	114
Industrial	16	0	0	0	0	16
Other	26	1	0	0	0	27
Pike						
Single Family	3,203	251	41	2	0	3,497
Other Residential	898	245	108	2	0	1,253
Commercial	12	4	1	0	0	17
Industrial	3	1	0	0	0	4
Other	4	1	0	0	0	5
Posey						
Single Family	7,717	272	40	2	0	8,031
Other Residential	984	166	54	1	0	1,205
Commercial	30	1	0	0	0	31
Industrial	9	0	0	0	0	9
Other	10	0	0	0	0	10

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Spencer						
Single Family	5,809	55	4	0	0	5,868
Other Residential	1,026	101	12	0	0	1,139
Commercial	45	1	0	0	0	46
Industrial	6	0	0	0	0	6
Other	25	1	0	0	0	26
Sullivan						
Single Family	5,673	53	4	0	0	5,730
Other Residential	1,230	125	15	0	0	1,370
Commercial	22	1	0	0	0	23
Industrial	1	0	0	0	0	1
Other	3	0	0	0	0	3
Vanderburgh						
Single Family	39,632	6,258	1,053	53	1	46,997
Other Residential	3,274	1,283	592	17	0	5,166
Commercial	455	192	79	6	0	732
Industrial	60	27	15	1	0	103
Other	1,055	487	240	18	0	1,800
Warrick						
Single Family	12,874	1,913	322	16	0	15,125
Other Residential	1,078	604	323	8	0	2,013
Commercial	61	25	10	1	0	97
Industrial	11	4	2	0	0	18
Other	10	3	1	0	0	14

Table 137: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Daviess	85	82	96.40	82	96.50	84	99.30	85	99.90	85	99.90
Dubois	218	210	96.40	210	96.50	216	99.30	218	99.90	218	99.90
Gibson	109	105	96.40	105	96.50	108	99.30	109	99.90	109	99.90
Greene	75	72	96.40	72	96.50	74	99.30	75	99.90	75	99.90
Knox	260	251	96.40	251	96.50	258	99.30	260	99.90	260	99.90
Pike	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Posey	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spencer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sullivan	35	34	96.40	34	96.50	35	99.30	35	99.90	35	99.90
Vanderburgh	1,319	546	41.40	553	41.90	843	63.90	1117	84.70	1130	85.70
Warrick	0	47	44.55	47	45.10	72	68.75	96	91.15	97	92.25

* Note: Discrepancies between the number of hospital beds and the percentage of beds may occur due to rounding.

Table 138: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Daviess	3	94.10
Dubois	5	94.10
Gibson	3	80.03
Greene	5	94.10
Knox	3	94.10
Pike	4	73.00
Posey	5	86.60
Spencer	2	94.10
Sullivan	3	94.10
Vanderburgh	7	46.07
Warrick	4	51.90

Table 139: School Functionality

Counties	Count	Functionality at Day 1 (%)
Daviess	21	88.07
Dubois	21	94.10
Gibson	20	84.86
Greene	14	94.10
Knox	18	94.10
Pike	5	85.66
Posey	14	81.82
Spencer	13	93.06
Sullivan	10	94.10
Vanderburgh	66	46.64
Warrick	21	53.41

Table 140: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Daviess	12	87.07
Dubois	14	94.10
Gibson	13	81.12
Greene	14	94.10
Knox	19	94.10
Pike	8	78.28
Posey	10	82.38
Spencer	7	90.53
Sullivan	12	94.10
Vanderburgh	26	46.82
Warrick	11	63.41

Table 141: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	167	99.70	99.90	99.90	99.90	99.90
Dubois	274	99.70	99.90	99.90	99.90	99.90
Gibson	235	93.08	98.78	99.28	99.80	99.88
Greene	155	99.80	99.90	99.90	99.90	99.90
Knox	301	99.70	99.90	99.90	99.90	99.90
Pike	127	93.11	98.81	99.31	99.83	99.89
Posey	200	92.99	98.69	99.19	99.73	99.87
Spencer	127	96.74	99.37	99.59	99.83	99.89
Sullivan	184	99.80	99.90	99.90	99.90	99.90
Vanderburgh	507	91.47	97.91	98.55	99.42	99.81
Warrick	213	93.09	98.79	99.29	99.81	99.88

Table 142: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	10,894	0.00	0.00	0.00	0.00	0.00
Dubois	14,813	0.00	0.00	0.00	0.00	0.00
Gibson	12,847	57.89	49.02	25.39	0.00	0.00
Greene	13,372	0.00	0.00	0.00	0.00	0.00
Knox	15,552	0.00	0.00	0.00	0.00	0.00
Pike	5,119	0.00	0.00	0.00	0.00	0.00
Posey	10,205	0.00	0.00	0.00	0.00	0.00
Spencer	7,569	0.00	0.00	0.00	0.00	0.00
Sullivan	7,819	0.00	0.00	0.00	0.00	0.00
Vanderburgh	70,623	51.93	40.36	11.06	0.00	0.00
Warrick	19,438	0.00	0.00	0.00	0.00	0.00

Table 143: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Daviess	2	93.7%	6.0%	0.4%	0.0%	0.0%
Dubois	3	93.7%	6.0%	0.4%	0.0%	0.0%
Gibson	1	49.6%	37.3%	11.3%	1.0%	0.8%
Greene	1	96.6%	3.2%	0.2%	0.0%	0.0%
Knox	1	93.7%	6.0%	0.4%	0.0%	0.0%
Pike	2	49.8%	37.4%	11.3%	1.0%	0.4%
Posey	1	49.6%	37.3%	11.3%	1.0%	0.8%
Spencer	1	49.6%	37.3%	11.3%	1.0%	0.8%
Sullivan	2	96.6%	3.2%	0.2%	0.0%	0.0%
Vanderburgh	1	49.6%	37.3%	11.3%	1.0%	0.8%
Warrick	1	50.0%	37.6%	11.4%	1.0%	0.1%

Table 144: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Daviess	1,178	6	2
Dubois	1,230	7	2
Gibson	1,515	86	314
Greene	1,430	8	2
Knox	1,487	8	2
Pike	935	5	1
Posey	1,296	11	16
Spencer	1,182	6	2
Sullivan	1,250	7	2
Vanderburgh	1,353	70	252
Warrick	1,211	7	2

Table 145: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	10,894	0.00	0.00	0.00	0.00	0.00
Dubois	14,813	0.00	0.00	0.00	0.00	0.00
Gibson	12,847	0.00	0.00	0.00	0.00	0.00
Greene	13,372	0.00	0.00	0.00	0.00	0.00
Knox	15,552	0.00	0.00	0.00	0.00	0.00
Pike	5,119	0.00	0.00	0.00	0.00	0.00
Posey	10,205	0.00	0.00	0.00	0.00	0.00
Spencer	7,569	0.00	0.00	0.00	0.00	0.00
Sullivan	7,819	0.00	0.00	0.00	0.00	0.00
Vanderburgh	70,623	0.00	0.00	0.00	0.00	0.00
Warrick	19,438	0.00	0.00	0.00	0.00	0.00

Table 146: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Daviess	5	93.7%	6.0%	0.4%	0.0%	0.0%
Dubois	6	93.7%	6.0%	0.4%	0.0%	0.0%
Gibson	5	49.9%	37.5%	11.3%	1.0%	0.2%
Greene	6	96.6%	3.2%	0.2%	0.0%	0.0%
Knox	3	93.7%	6.0%	0.4%	0.0%	0.0%
Pike	3	50.0%	37.6%	11.4%	1.0%	0.1%
Posey	3	49.7%	37.4%	11.3%	1.0%	0.6%
Spencer	7	68.7%	24.0%	6.6%	0.6%	0.0%
Sullivan	6	96.6%	3.2%	0.2%	0.0%	0.0%
Vanderburgh	3	49.7%	37.4%	11.3%	1.0%	0.6%
Warrick	5	49.7%	37.4%	11.3%	1.0%	0.7%

Table 147: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Daviess	707	5	1
Dubois	738	5	1
Gibson	909	68	248
Greene	858	6	2
Knox	892	6	2
Pike	561	4	1
Posey	777	8	12
Spencer	710	5	1
Sullivan	750	5	1
Vanderburgh	812	55	199
Warrick	727	5	1

Table 148: Highway Bridge Damage

Counties	# of Bridges	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Daviess	136	98.62%	0.96%	0.25%	0.13%	0.02%
Dubois	192	99.55%	0.29%	0.08%	0.05%	0.01%
Gibson	293	92.32%	0.22%	0.06%	6.31%	1.06%
Greene	201	99.41%	0.38%	0.12%	0.07%	0.01%
Knox	288	99.35%	0.40%	0.14%	0.09%	0.01%
Pike	136	94.36%	0.19%	0.04%	5.02%	0.36%
Posey	191	96.06%	0.31%	0.17%	2.84%	0.60%
Spencer	212	94.24%	0.16%	0.11%	5.09%	0.37%
Sullivan	204	99.11%	0.60%	0.17%	0.09%	0.01%
Vanderburgh	188	90.87%	0.54%	0.09%	5.04%	3.43%
Warrick	173	94.17%	0.29%	0.09%	4.48%	0.95%

Table 149: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	136	99.36	99.67	99.76	99.78	99.84
Dubois	192	99.75	99.83	99.86	99.87	99.88
Gibson	293	92.73	92.80	92.92	93.47	96.69
Greene	201	99.67	99.79	99.84	99.85	99.87
Knox	288	99.63	99.76	99.82	99.83	99.87
Pike	136	94.67	94.72	94.81	95.25	97.77
Posey	191	96.41	96.54	96.64	96.90	98.35
Spencer	212	94.55	94.62	94.74	95.18	97.74
Sullivan	204	99.55	99.74	99.81	99.82	99.86
Vanderburgh	188	91.51	91.68	91.79	92.27	95.01
Warrick	173	94.56	94.66	94.76	95.16	97.45

Indiana – Wabash Valley Seismic Zone Scenario

This scenario for the State of Indiana includes the same set of 11 critical counties as listed in the NMSZ scenario discussion. As mentioned earlier, both scenarios produce the most substantial shaking in southwestern Indiana and thus the same set of counties is used. For a comparison of ground shaking values for the two Indiana scenarios please reference Appendix I.

The scenario consists of a M_w7.1 earthquake along the Wabash Valley Fault system. The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS). Though the Wabash Valley Seismic Zone (WVSZ) covers significant area in southern Illinois, the actual fault modeled by the USGS is much shorter than the NMSZ faults. Figure 6 illustrates the location of the Wabash Valley fault utilized in the creation of USGS shaking maps for this seismic zone.

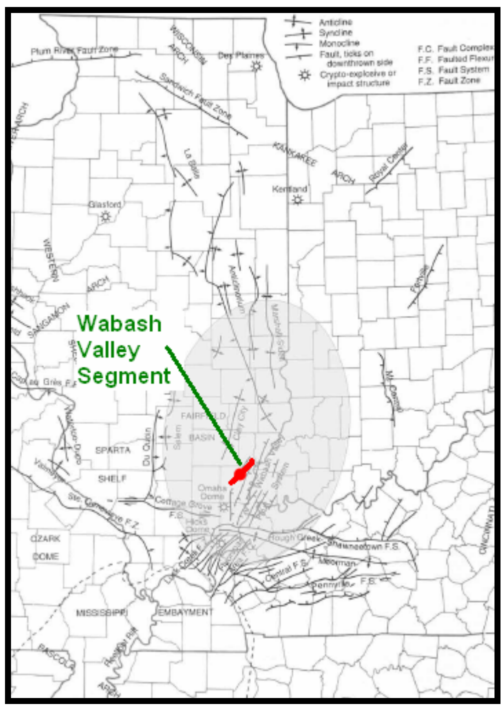

Figure 6: Wabash Valley Seismic Zone Fault for the State of Indiana

The WVSZ scenario generates thousands of cases of complete damage which is much greater than the level of complete damage from the NMSZ scenario. The fault rupture is much closer to the State of Indiana and thus the shaking is far more intense, particularly in the critical counties. Again, residential structures incur the majority of damage, both moderate and complete. Residential structures account for over 95% of all complete damage with single family homes contributing over 85% of complete damage cases. Moderate and severe dame shows similar estimates with single family homes incurring 70% of all moderate damage.

Nearly all complete damage, nearly 97%, occurs in the 11 critical counties in southwestern Indiana. Only 20% of all moderate and severe building damage occurs in this area, indicating that the moderate level of shaking outside the critical counties is enough to cause significant cracking of concrete and unreinforced masonry. With this many extreme damage cases in the critical counties and moderate damage extending to the north and west of that area, numerous people will be displaced over a much larger set of counties in Indiana.

Table 150: Damage by General Occupancy Type for the State of Indiana

General Occupancy Type Damage (State level)			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	1,675,434	5,315	7,464
Other Residential	229,169	2,068	1,161
Commercial	19,034	200	90
Industrial	4,317	30	15
Other	4,102	31	224
Total	1,932,056	7,644	8,954

Table 151: Damage by General Occupancy Type for the 11 Critical Counties

General Occupancy Type Damage (11 Critical Counties)			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	133,792	926	7,228
Other Residential	21,966	540	1,085
Commercial	1,410	24	90
Industrial	279	7	15
Other	1,967	6	224
Total	159,414	1,503	8,642

Table 152: Building Damage by Building Type for the State of Indiana

Building Damage by Building Type					
Building Type	None	Slight	Moderate	Extensive	Complete
Wood	1,370,489	19,342	515	24	6,305
Steel	8,545	222	83	4	101
Concrete	2,655	72	13	0	44
Precast	2,912	107	46	2	51
Reinforced Masonry	1,717	41	15	0	14
Unreinforced Masonry	330,681	21,176	4,936	227	1,683
Mobile Home	148,359	9,140	1,767	13	756
Total	1,865,358	50,100	7,374	270	8,954

Building damage by building type is illustrated in Table 152 for the entire State of Indiana. The WVSZ scenario shows a substantial number of wood frame collapses though very few occurrences of damage in the less severe damage states. This is likely

due to liquefaction in the critical counties causing substantial settlements that damage structures severely. Roughly 70% of all complete damage is experienced by wood frame structures and nearly another 20% is attributed to URMs. Moderate damage is more common in URMs and mobile homes than any other type of construction.

Table 153: Essential Facilities Damage & Functionality for the State of Indiana[6]

Essential Facilities Damage & Functionality				
Essential Facility Type	Total No. Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
Hospitals	175	0	0	174
Schools	2,686	0	0	2,666
EOCs	51	0	0	49
Police Stations	474	0	0	466
Fire Stations	1,210	0	0	1,195

Table 154: Essential Facilities Damage & Functionality for the 11 Critical Counties

Essential Facilities Damage & Functionality				
Essential Facility Type	Total No. Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
Hospitals	16	0	0	15
Schools	223	0	0	203
EOCs	6	0	0	4
Police Stations	44	0	0	36
Fire Stations	146	0	0	131

Most essential facilities are not likely to incur moderate damage due to the WVSZ event, though lese severe damage levels are possible. While no essential facilities are expected to experience substantial damage some will have reduced functionality. Schools report the greatest loss of functionality with 20 schools not operating in Knox and Posey Counties. In addition, 15 fire stations 8 police stations and a hospital are not operating immediately after the earthquake. Most of these facilities are located in Know, Gibson, Posey and Dubois Counties. All facilities outside of the critical counties are fully operational the day after the earthquake.

[6] For Tables 153-163 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as ‘damaged’. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed ‘undamaged’.

Table 155: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	2,220	0	0	2,220
Remaining Counties	14,285	0	0	14,285
Total State	16,505	0	0	16,505

Table 156: Airport Damage Assessments

Airport Damage Assessments				
	Total No. Of Airports	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	49	0	0	47
Remaining Counties	447	0	0	447
Total State	496	0	0	494

Table 157: Transportation System Damage for the State of Indiana

Transportation System Damage					
Transportation System	Type	Quantity	At Least Moderate Damage (Damage>50%)	Complete Damage (Damage >50%)	Functionality at Day 1 < 50%
Highway	Segments	2,844	0	0	2,844
	Bridges	16,505	0	0	16,505
	Tunnels	0	0	0	0
Railways	Segments	4,988	0	0	4,988
	Bridges	92	0	0	92
	Tunnels	8	0	0	8
	Facilities	91	0	0	91
Bus	Facilities	46	1	0	46
Light Rail	Segments	15	0	0	15
	Bridges	0	0	0	0
	Facilities	13	13	13	0
Ferry	Facilities	0	0	0	0
Port	Facilities	91	0	0	91
Airport	Facilities	496	5	0	494
	Runways	538	0	0	538

Transportation facilities and networks are similar to essential facilities in so far as facilities are not damaged significantly but there is some reduced functionality. Functionalities differ from damage states in that functionalities indicate the operational capabilities of various infrastructure components and do not indicate the level of damage sustained by that particular component. Damage state calculations are separate from

functionality calculations in impact assessment modeling. For example, a highway bridge may sustain minor damage, but still remain operational. Conversely, a bridge suffering severe structural damage and substantial settlement is likely not able to be used. The WVSZ scenario only impairs the functionality of several airports and those are located within the critical counties. All transportation lifelines outside the critical counties are fully operational the day after the earthquake.

There are no instances of complete damage to any utility facilities in the 11 critical counties or the remainder of the state. Numerous types of facilities, however, show cases of moderate or severe damage. Electric power and communication facilities show the most cases of damage with 23 and 435 moderately or severely damaged facilities, respectively. This level of damage impairs the functionality of all utility facilities, particularly in southwestern Indiana. Over 20 waste water facilities are estimated to be non-functional the day after the event in the 11 critical counties alone. Ten oil facilities will not be operational, which may impede the transport of oil through the central U.S. to other portions of the country. Over half, or 53, of all electric power facilities in southwestern Indiana are not operational meaning they can not provide power to customers. Those customers that did not experience substantial structural damage to their homes may be displaced due to lack of power, or even potable water. Furthermore, emergency response efforts may be impeded by the lack of electric power. Communication facilities report the greatest loss of functionality with over 130 facilities non-operational in the days immediately following the event. Without communication facilities functioning properly it may be difficult to coordinate emergency response and aid efforts.

Table 158: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	16	4	0	12
Remaining Counties	80	0	0	80
Total State	96	4	0	92

Table 159: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	52	4	0	30
Remaining Counties	394	0	0	394
Total State	446	4	0	424

Table 160: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
11 Critical Counties	7	0	0	7
Remaining Counties	22	0	0	22
Total State	29	0	0	29

Table 161: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
11 Critical Counties	35	3	0	25
Remaining Counties	135	0	0	135
Total State	170	3	0	160

Table 162: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	97	23	0	44
Remaining Counties	695	0	0	695
Total State	792	23	0	739

Table 163: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
11 Critical Counties	2,490	432	0	2,359
Remaining Counties	19,189	3	0	19,189
Total State	21,679	435	0	21,548

Pipeline damage is estimated for local potable water, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not present in the default inventory, or local inventory in HAZUS-MH MR2, though regional, or major transmission, oil pipelines are added from HSIP 2007 data to provide estimates for these major oil transmission lines. These oil pipelines are comprised of major crude oil and refined product lines only. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at 2,613 and 1,032, respectively. Local natural gas lines, however, show the greatest break and leak rates per length of pipe

at roughly 0.023 leaks/mile (roughly 1 leak every 43 miles) or 0.051 breaks/mile (roughly 1 break every 20 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of approximately 1,100 leaks and 2,400 breaks over the combined length of 54,746 miles of natural gas pipeline.

Potable water service is cut off to over 42,000 residences the day after the scenario earthquake. This is reduced to 26,800 residences within a week, and all service is restored after three months. This period of time without water prevents people from remaining in their homes in the weeks immediately following the earthquake. As a result of the moderate level of shaking, electric power service is interrupted to nearly 15,000 residences in Indiana the day after the earthquake. Over 4,000 residences are still without power after one week. Almost all disruptions in potable water service and electrical power service occur in the 11 critical counties.

Table 164: Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	111,394	1,032	2,613
Waste Water - Local	66,836	816	2,067
Natural Gas - Regional	10,188	31	111
Natural Gas - Local	44,558	1,046	2,252
Oil - Regional	4,625	56	219

Table 165: Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households (Critical Counties)	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	188,251	42,022*	31,248	26,786	18,504	0
Electric Power		14,994	9,419	4,185	1,169	19

NOTE: All disruptions to potable water service and electrical power service occur in the 11 critical counties with the exception of 441 households that lose potable water service in Day 1.

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage level available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county. The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as

discussed in footnote (6) and employed in the preceding table for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Dubois County, Indiana – 192 highway bridges
  - Estimation procedure according to footnote 6:
    - Summation of individual bridges after that bridges is deemed ‘damaged’ or ‘undamaged’ based on 50% or greater damage likelihood requirement estimates **0 at least moderately damaged highway bridges**
  - Estimation procedure according to topic damage tables in this appendix:
    - To determine the percentage of highway bridges in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of bridges in that county
    - Using these damage state probabilities averaged over all the bridges in the county provides an estimate of **8 at least moderately damaged highway bridges**

In the case of Dubois County, Indiana, the topic damage tables in this appendix provide a higher estimate of damage as opposed to the waste water facility damage summation detailed in footnote (6). Though not illustrated here, other counties in Indiana are estimated to incur lesser damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged highway bridges for the 11 critical counties in Indiana shows the following:

- Total number of at least moderately damaged highway bridges according to the HAZUS-MH MR2 procedure for averaging damage at the county level
  - **146 at least moderately damaged highway bridges**
- Total number of at least moderately damaged highway bridges according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
  - **0 at least moderately damaged highway bridges**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces more damage. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix for the WVSZ scenario in Indiana.

The following tables provide damage and functionality estimates for the WVSZ scenario critical counties in Indiana. These tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage level for a county.

Table 166: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Daviess						
Single Family	7,267	694	103	12	28	8,104
Other Residential	1,099	207	55	1	4	1,366
Commercial	62	11	3	0	0	76
Industrial	11	1	0	0	0	12
Other	18	2	0	0	0	20
Dubois						
Single Family	9,659	990	146	6	0	10,801
Other Residential	1,176	199	47	1	0	1,423
Commercial	102	22	7	0	0	131
Industrial	77	11	4	0	0	92
Other	15	2	1	0	0	18
Gibson						
Single Family	7,121	829	123	10	1,398	9,481
Other Residential	1,101	339	95	1	324	1,860
Commercial	44	10	3	0	6	63
Industrial	6	1	1	0	1	9
Other	15	3	1	0	3	22
Greene						
Single Family	9,051	45	3	0	0	9,099
Other Residential	3,376	92	5	0	0	3,473
Commercial	77	1	0	0	0	78
Industrial	9	0	0	0	0	9
Other	20	0	0	0	0	20
Knox						
Single Family	7,753	1,321	188	12	1,784	11,058
Other Residential	965	346	92	2	294	1,699
Commercial	69	17	5	0	22	113
Industrial	10	2	1	0	4	17
Other	16	4	1	0	5	26
Pike						
Single Family	3,366	115	16	1	0	3,498
Other Residential	1,055	157	41	0	0	1,253
Commercial	16	1	0	0	0	17
Industrial	4	0	0	0	0	4
Other	4	0	0	0	0	5
Posey						
Single Family	6,589	1,001	151	15	276	8,032
Other Residential	745	327	95	2	36	1,205
Commercial	21	5	2	0	2	30
Industrial	6	2	1	0	1	10
Other	8	2	1	0	1	12

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Spencer						
Single Family	5,837	29	2	0	0	5,868
Other Residential	1,108	29	2	0	0	1,139
Commercial	46	0	0	0	0	46
Industrial	6	0	0	0	0	6
Other	26	0	0	0	0	26
Sullivan						
Single Family	4,931	672	98	5	25	5,730
Other Residential	948	325	92	1	5	1,371
Commercial	17	4	1	0	0	22
Industrial	1	0	0	0	0	1
Other	2	1	0	0	0	3
Vanderburgh						
Single Family	42,962	287	26	5	3,718	46,998
Other Residential	4,663	75	5	0	422	5,165
Commercial	666	7	1	0	59	733
Industrial	93	1	0	0	9	103
Other	1,565	17	2	0	216	1,800
Warrick						
Single Family	15,045	75	5	0	0	15,125
Other Residential	1,960	49	3	0	0	2,013
Commercial	96	1	0	0	0	97
Industrial	18	0	0	0	0	18
Other	15	0	0	0	0	15

Table 167: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Daviess	85	56	65.50	56	66.00	73	85.60	84	98.40	84	98.80
Dubois	218	144	66.10	145	66.60	189	86.50	216	99.20	217	99.60
Gibson	109	71	65.50	72	66.00	93	85.60	107	98.40	108	98.80
Greene	75	74	98.10	74	98.10	75	99.60	75	99.90	75	99.90
Knox	260	129	49.60	130	49.90	168	64.80	193	74.40	194	74.70
Pike	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Posey	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Spencer	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Sullivan	35	23	66.10	23	66.60	30	86.50	35	99.20	35	99.60
Vanderburgh	1,319	1137	86.20	1137	86.20	1155	87.60	1158	87.80	1159	87.90
Warrick	0	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00

*Note: Discrepancies between the number of hospital beds and the percentages of beds may occur due to rounding.

Table 168: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Daviess	3	69.47
Dubois	5	63.08
Gibson	3	69.47
Greene	5	96.60
Knox	3	45.83
Pike	4	96.60
Posey	5	49.20
Spencer	2	96.60
Sullivan	3	69.80
Vanderburgh	7	80.83
Warrick	4	96.60

Table 169: School Functionality

Counties	Count	Functionality at Day 1 (%)
Daviess	21	71.40
Dubois	21	73.30
Gibson	20	65.99
Greene	14	96.60
Knox	18	46.83
Pike	5	88.56
Posey	14	58.04
Spencer	13	92.28
Sullivan	10	68.27
Vanderburgh	66	86.25
Warrick	21	95.37

Table 170: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Daviess	12	75.08
Dubois	14	82.24
Gibson	13	71.55
Greene	14	96.60
Knox	19	50.94
Pike	8	91.58
Posey	10	50.71
Spencer	7	91.59
Sullivan	12	62.54
Vanderburgh	26	86.95
Warrick	11	96.60

Table 171: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	167	84.05	95.77	97.25	99.55	99.88
Dubois	274	93.17	98.87	99.37	99.88	99.90
Gibson	235	78.26	92.40	94.50	98.31	99.67
Greene	155	88.98	97.48	98.44	99.77	99.90
Knox	301	56.36	77.04	82.38	93.90	98.88
Pike	127	91.76	98.39	99.05	99.83	99.90
Posey	200	86.39	96.46	97.67	99.53	99.87
Spencer	127	93.11	98.81	99.31	99.84	99.90
Sullivan	184	65.64	85.20	89.51	97.92	99.61
Vanderburgh	507	93.13	98.71	99.21	99.77	99.90
Warrick	213	93.14	98.84	99.34	99.86	99.90

Table 172: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	10,894	0.00	0.00	0.00	0.00	0.00
Dubois	14,813	0.00	0.00	0.00	0.00	0.00
Gibson	12,847	94.15	93.34	91.29	40.71	0.00
Greene	13,372	0.00	0.00	0.00	0.00	0.00
Knox	15,552	97.72	97.45	96.82	85.35	0.00
Pike	5,119	0.00	0.00	0.00	0.00	0.00
Posey	10,205	0.00	0.00	0.00	0.00	0.00
Spencer	7,569	0.00	0.00	0.00	0.00	0.00
Sullivan	7,819	0.00	0.00	0.00	0.00	0.00
Vanderburgh	70,623	20.23	5.81	0.00	0.00	0.00
Warrick	19,438	0.00	0.00	0.00	0.00	0.00

Table 173: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Daviess	2	19.7%	42.2%	30.8%	6.6%	0.7%
Dubois	3	49.9%	37.5%	11.3%	1.0%	0.2%
Gibson	1	6.8%	27.3%	35.7%	13.6%	16.6%
Greene	1	50.0%	37.6%	11.4%	1.0%	0.1%
Knox	1	7.9%	31.9%	41.6%	15.9%	2.6%
Pike	2	49.9%	37.5%	11.3%	1.0%	0.3%
Posey	1	49.8%	37.4%	11.3%	1.0%	0.5%
Spencer	1	49.8%	37.4%	11.3%	1.0%	0.5%
Sullivan	2	2.0%	15.3%	39.0%	32.6%	11.0%
Vanderburgh	1	49.8%	37.4%	11.3%	1.0%	0.5%
Warrick	1	50.0%	37.6%	11.4%	1.0%	0.1%

Table 174: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Daviess	1,178	5	4
Dubois	1,230	4	1
Gibson	1,515	243	950
Greene	1,430	5	1
Knox	1,487	339	1,335
Pike	935	3	1
Posey	1,296	9	20
Spencer	1,182	4	1
Sullivan	1,250	8	17
Vanderburgh	1,353	38	132
Warrick	1,211	4	1

Table 175: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	10,894	0.00	0.00	0.00	0.00	0.00
Dubois	14,813	0.00	0.00	0.00	0.00	0.00
Gibson	12,847	0.00	0.00	0.00	0.00	0.00
Greene	13,372	0.00	0.00	0.00	0.00	0.00
Knox	15,552	73.08	47.38	22.47	6.83	0.09
Pike	5,119	0.00	0.00	0.00	0.00	0.00
Posey	10,205	0.00	0.00	0.00	0.00	0.00
Spencer	7,569	0.00	0.00	0.00	0.00	0.00
Sullivan	7,819	46.40	26.23	8.82	1.37	0.06
Vanderburgh	70,623	0.00	0.00	0.00	0.00	0.00
Warrick	19,438	0.00	0.00	0.00	0.00	0.00

Table 176: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Daviess	5	31.5%	39.5%	22.4%	4.2%	2.4%
Dubois	6	50.0%	37.6%	11.3%	1.0%	0.1%
Gibson	5	25.6%	40.9%	26.6%	5.4%	1.5%
Greene	6	45.0%	38.4%	14.6%	1.9%	0.2%
Knox	3	10.2%	30.8%	36.4%	14.8%	7.8%
Pike	3	50.0%	37.6%	11.4%	1.0%	0.1%
Posey	3	29.4%	39.9%	23.8%	4.6%	2.2%
Spencer	7	50.0%	37.6%	11.3%	1.0%	0.1%
Sullivan	6	15.8%	38.8%	34.4%	9.7%	1.3%
Vanderburgh	3	49.9%	37.5%	11.3%	1.0%	0.3%
Warrick	5	49.8%	37.5%	11.3%	1.0%	0.4%

Table 177: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Daviess	707	4	3
Dubois	738	4	1
Gibson	909	192	751
Greene	858	4	1
Knox	892	268	1,056
Pike	561	3	1
Posey	777	7	16
Spencer	710	3	1
Sullivan	750	7	13
Vanderburgh	812	30	105
Warrick	727	3	1

Table 178: Highway Bridge Damage

Counties	# of Bridges	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Daviess	136	93.72%	0.95%	0.18%	1.24%	3.90%
Dubois	192	94.87%	0.25%	0.12%	4.28%	0.45%
Gibson	293	88.58%	0.25%	0.05%	2.57%	8.52%
Greene	201	97.81%	0.30%	0.20%	1.26%	0.41%
Knox	288	86.16%	1.90%	0.10%	1.89%	9.93%
Pike	136	93.77%	0.14%	0.04%	3.73%	2.31%
Posey	191	93.96%	0.36%	0.19%	1.05%	4.42%
Spencer	212	94.13%	0.12%	0.13%	5.36%	0.25%
Sullivan	204	95.13%	1.76%	0.13%	0.41%	2.56%
Vanderburgh	188	92.83%	0.23%	0.07%	5.82%	1.02%
Warrick	173	94.82%	0.18%	0.07%	4.49%	0.42%

Table 179: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Daviess	136	94.54	94.83	94.91	95.08	95.97
Dubois	192	95.22	95.32	95.40	95.80	97.97
Gibson	293	89.00	89.07	89.14	89.48	91.35
Greene	201	98.09	98.21	98.30	98.43	99.08
Knox	288	87.81	88.35	88.42	88.72	90.34
Pike	136	94.02	94.07	94.12	94.49	96.50
Posey	191	94.35	94.49	94.58	94.74	95.57
Spencer	212	94.42	94.49	94.58	95.08	97.77
Sullivan	204	96.48	96.96	97.02	97.09	97.47
Vanderburgh	188	93.23	93.32	93.39	93.94	96.91
Warrick	173	95.11	95.18	95.24	95.66	97.92

Kentucky – New Madrid Seismic Zone Scenario

This earthquake impact assessment includes all 120 counties in the State of Kentucky. Kentucky is approximately 40,400 square miles and is bordered by Indiana and Ohio to the north, Tennessee to the south, West Virginia and Virginia to the east and Illinois and Missouri to the west. For the purposes of this analysis, 25 critical counties have been identified in the western portion of the state where shaking is anticipated to be most intense. These 25 counties are the focus of much of the damage assessment included within this document. The critical counties are listed below:

- Ballard
- Caldwell
- Calloway
- Carlisle
- Christian
- Crittenden
- Daviess
- Fulton
- Graves
- Hancock
- Henderson
- Hickman
- Hopkins
- Livingston
- Logan
- Lyon
- McCracken
- McLean
- Marshall
- Muhlenberg
- Ohio
- Todd
- Trigg
- Union
- Webster

The NMSZ scenario for the State of Kentucky consists of a magnitude 7.7 (M_w7.7) earthquake along the northeast extension of the presumed eastern fault line in the New Madrid fault system. The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS) for the middle fault in the proposed New Madrid Seismic Zone (NMSZ). Each fault line is presumed to consist of three fault segments; northeastern, central, and southwestern. This scenario, the worst case event for Kentucky, employs an event in the northeast segment of the eastern fault. The location of this scenario event is illustrated in Figure 7. For more information on the ground motion used in this scenario please reference Appendix I.

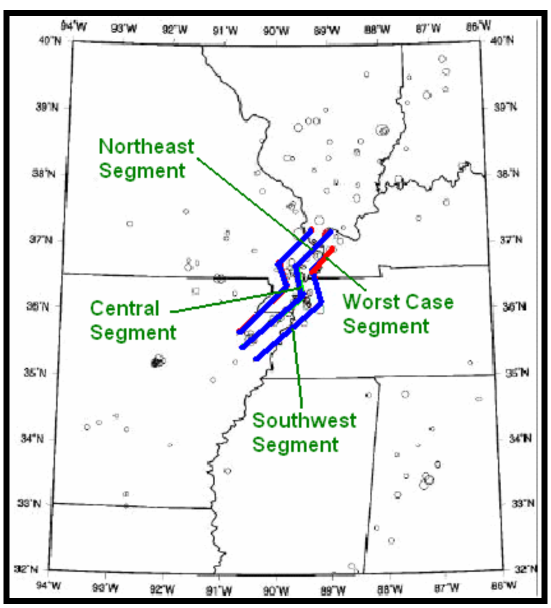

Figure 7: Scenario Fault Location for the State of Kentucky

Within the State of Kentucky, nearly 29,000 buildings experience complete damage, which are included in the nearly 53,000 at least moderately damaged buildings. While this is roughly 2% of all Kentucky buildings, many of these collapsed structures are concentrated in the western counties. As with previous state scenarios, residential buildings experience the greatest amount of damage. Nearly 98% of all building collapses occur to residential structures. In addition, about 94% of all at least moderate damage occurs in the 25 critical counties for Kentucky.

Table 180: Damage by General Occupancy Type for the State of Kentucky

General Occupancy Type Damage (State level)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,159,114	39,150	18,768
Other Residential	292,873	13,050	9,673
Commercial	16,431	306	475
Industrial	3,002	48	53
Other	1,900	34	60
Total	1,473,320	52,588	29,029

Table 181: Damage by General Occupancy Type for the 25 Critical Counties

General Occupancy Type Damage (25 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	189,655	38,707	18,652
Other Residential	50,493	10,619	9,619
Commercial	1,682	259	475
Industrial	265	37	53
Other	242	29	60
Total	242,337	49,651	28,859

Wood frame construction is the most common type of building in the State of Kentucky and also generates the most cases of complete damage. Over 47% of all collapses, 13,700 buildings, is experienced by wood frame structures. Unreinforced masonry (URM) construction and mobile homes (MH) also show high frequencies of collapse and account for nearly all non-wood construction building collapses. This damage state is identified by significant cracking to unreinforced masonry walls as well as some connection damage to column/beam joints in unreinforced masonry building. The remaining building types show far less inventory throughout the state and thus experience a far lesser proportion of damage.

Table 182: Building Damage by Building Type for the State of Kentucky

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	992,135	18,737	24,772	11,617	13,726
Steel	6,430	264	93	39	201
Concrete	1,782	51	22	15	58
Precast	1,907	74	42	19	69
Reinforced Masonry	1,109	20	13	10	39
Unreinforced Masonry	137,881	8352	2,434	1,720	6,161
Mobile Home	197,127	25935	7,952	3,840	8,775
Total	1,338,371	53,433	35,328	17,260	29,029

Of the 1,066 fire stations in the state, 77 (more than 7%) are estimated to experience at least moderate damage. Approximately 5-7% of most other essential facility types (schools, hospitals, and police stations) each sustain at least moderate damage. In addition, 79 of the 1,846 schools and 61 fire stations are estimated to collapse. All of these facilities are in the most western counties in Kentucky. The Kentucky inventory does not specify any locations for emergency operations centers, thus no damage can be determined for this type of essential facility.

Not only are numerous facilities damaged but many facilities located in the western portion of Kentucky are not functional in the days immediately after the earthquake. All of the non-functional facilities are located in the western portion of the state. Of Kentucky's 135 hospitals, 118 are considered functional the day after the earthquake and after one week that number increases to 129 functional facilities. Roughly 90% of all fire stations and police stations in Kentucky are estimated to remain functional the day after the earthquake, though all of these functioning facilities are located in the central and eastern portions of the state. Most of Kentucky's western counties are left without functioning facilities and will likely experience diminished services in the immediate aftermath of an earthquake.

Transportation lifelines, particularly in western Kentucky counties incur the most severe damage. Roughly 200 of the 6,800, or approximately 3% of all bridges, are estimated to incur at least moderate damage. Of the nearly 200 damaged bridges, almost 50 are expected to collapse. These collapses are shown to occur in counties along the western border of Kentucky. Highway road segments connecting these damaged bridges are expected to incur slightly less damage than the bridges themselves, even in the counties with the most severe shaking. Highway segments are most generally defined as a section of highway between two end nodes. These end nodes are frequently highway bridges. At least moderate damage to highway bridges is characterized by moderate shear (diagonal) cracking of columns, spalling of cover concrete and shear keys, abutment movement less than two-inches, extensive cracking to shear keys, bent connection bolts, and moderate settlement of the bridge approaches.

Table 183: Essential Facilities Damage & Functionality for the State of Kentucky[7]

Essential Facilities Damage & Functionality (State)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	135	6	4	118
Schools	1,846	98	79	1,713
EOCs	0	0	0	0
Police Stations	407	23	19	373
Fire Stations	1,066	77	61	959

Table 184: Essential Facilities Damage & Functionality for the 25 Critical Counties

Essential Facilities Damage & Functionality (25 Critical Counties)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	21	6	4	5
Schools	301	98	79	168
EOCs	0	0	0	0
Police Stations	77	23	19	44
Fire Stations	238	77	61	133

Table 185: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Bridges	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
25 Critical Counties	2,173	197	46	1,974
Remaining Counties	4,632	0	0	4,630
Total State	6,805	197	46	6604

Table 186: Airport Damage Assessments

Airport Damage Assessments				
	Total No. Of Airports	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
25 Critical Counties	53	19	1	40
Remaining Counties	166	0	0	166
Total State	219	19	1	206

[7] For Tables 183-193 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Furthermore, 86 ports, 23 railway facilities and 19 airports reach at least moderate damage state and follow roughly the same damage distribution throughout the state as highway bridges. At least moderate damage to port facilities includes considerable ground settlement, derailment of port equipment and damage to structural members. For airports, at least moderate damage is defined in the same manner as damage to other building types discussed previously. The lack of functionality of many transportation lifelines in western Kentucky will make the movement of people and supplies difficult in the days immediately following the earthquake.

Table 187: Transportation System Damage for the State of Kentucky

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	9,481	0	0	9,481
	Bridges	6,805	197	46	6,604
	Tunnels	4	0	0	4
Railways	Segments	2,761	0	0	2,761
	Bridges	166	3	0	163
	Tunnels	18	0	0	18
	Facilities	117	23	0	96
Bus	Facilities	26	2	0	25
Light Rail	Segments	0	0	0	0
	Bridges	0	0	0	0
	Facilities	0	0	0	0
Ferry	Facilities	16	16	16	0
Port	Facilities	301	86	14	221
Airport	Facilities	219	19	1	206
	Runways	155	0	0	155

Table 188: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
25 Critical Counties	36	11	0	27
Remaining Counties	143	0	0	143
Total State	179	11	0	170

Utility lifelines' damage and functionality are similar to those found for the transportation systems. Over 500 waste water facilities are moderately or more severely damaged while 81 incur complete damage. Approximately 1,050 communication facilities incur at least moderate damage, while 133 experience complete damage. Additionally, 8% of all electric power facilities reach at least moderate damage state.

Table 189: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	1,561	523	81	764
Remaining Counties	7,530	0	0	7,530
Total State	9,081	523	81	8,294

Table 190: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
25 Critical Counties	24	6	4	0
Remaining Counties	313	0	0	313
Total State	337	6	4	313

Table 191: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
25 Critical Counties	31	6	1	23
Remaining Counties	57	0	0	57
Total State	88	6	1	80

Table 192: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	463	132	40	231
Remaining Counties	1,230	0	0	1,230
Total State	1,693	132	40	1,461

Table 193: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	3,262	1,044	133	2,410
Remaining Counties	13,095	0	0	13,095
Total State	16,357	1,044	133	15,505

Pipeline damage is estimated for local potable water, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not included in the HAZUS-MH MR2 default inventory, called local inventory in HAZUS-MH MR2, though regional oil pipelines are added to provide damage estimates for these major oil transmission lines. These oil pipelines are composed of major crude oil and refined product lines only. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at roughly 7,283 and 7,804, respectively. Local natural gas lines experience the greatest leak and break rates per length of pipe, at roughly 0.16 leaks/mile (1 leak every 6.2 miles) and approximately 0.15 breaks/mile (1 break every 6.7 miles), respectively. In addition, estimates for local and regional damage to natural gas lines can be combined for a total state damage estimate of 6,702 leaks and 6,457 breaks over the combined length of 48,499 miles of natural gas pipeline.

Potable water service is cut off to nearly 109,000 residences the day after the scenario earthquake. This number is reduced to roughly 67,000 residences within a week. After three months, potable water service is restored for all residences, as shown in Table 195. These estimates are calculated employing a formula that uses the damage to the distribution system to determine the rate of repair. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program. This period of time without water prevents thousands of people from remaining in their homes in the weeks and months following the earthquake. Electric power service shows similar trends, with over 77,000 residences without electric power the day after the earthquake, or nearly 5% of all State residences. Even a month after the earthquake, over 36,000 residences are still without power. All electric power lines in Kentucky are presumed to be above ground and less likely to incur damage from moderate ground shaking, unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation.

Table 194: Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	102,749	7,804	7,283
Waste Water - Local	61,650	6,173	5,760
Natural Gas - Regional	7,399	104	300
Natural Gas - Local	41,100	6,598	6,157
Oil - Regional	1,165	43	116

Table 195: Utility Service Interruptions for the State of Kentucky

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	1,590,647	108,556	92,742	66,608	38,694	0
Electric Power		77,263	60,273	36,450	11,464	86

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county. The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as discussed in footnote (7) and employed in the preceding damage tables for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Lyon County, Kentucky – 33 waste water facilities
    - Estimation procedure according to footnote 7:
        - Summation of individual facilities after that facility is deemed 'damaged' or 'undamaged' based on 50% or greater damage likelihood requirement estimates **24 at least moderately damaged waste water facilities**
    - Estimation procedure according to topic damage tables in this appendix:
        - To determine the percentage of waste water facilities in the at least moderate damage category add the percentages for moderate, extensive and complete damage county then multiply by the number of facilities in that county
        - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **18 at least moderately damages waste water facilities**

In the case of Lyon County, Kentucky, the topic damage tables in this appendix provide a lower estimate of damage as oppose to the facility-by-facility damage summation detailed in footnote (7). Though not illustrated here, other counties in Kentucky are estimated to incur greater damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged waste water facilities for the 25 critical counties in Kentucky shows the following:

- Total number of at least moderately damaged waste water facilities according to the HAZUS-MH MR2 procedure for averaging damage at the county level
    - **663 at least moderately damaged waste water facilities**
- Total number of at least moderately damaged waste water facilities according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
    - **523 at least moderately damaged waste water facilities**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces greater damage. This trend holds true for other infrastructure types including highway bridges.

The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Kentucky. There tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage levels for a county.

Table 196: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Ballard						
Single Family	5	172	1,038	722	749	2,686
Other Residential	0	1	40	158	562	761
Commercial	0	0	0	2	13	15
Industrial	0	0	0	0	6	6
Other	0	0	0	0	4	4
Caldwell						
Single Family	3,696	495	61	4	6	4,262
Other Residential	440	327	180	5	2	954
Commercial	22	9	4	0	0	35
Industrial	3	2	1	0	0	6
Other	2	0	0	0	0	2
Calloway						
Single Family	2,030	4,143	2,463	368	615	9,619
Other Residential	412	748	1,192	910	381	3,643
Commercial	3	16	47	35	17	118
Industrial	0	0	2	2	1	5
Other	0	32	5	54	2	93
Carlisle						
Single Family	1	45	455	633	607	1,741
Other Residential	0	0	1	23	471	495
Commercial	0	0	0	0	12	12
Industrial	0	0	0	0	2	2
Other	0	0	0	0	5	5
Christian						
Single Family	14,778	1,980	242	11	0	17,011
Other Residential	2,235	1,265	654	17	0	4,171
Commercial	99	42	17	1	0	159
Industrial	17	8	5	0	0	30
Other	15	5	2	0	0	22
Crittenden						
Single Family	2,321	311	38	2	0	2,672
Other Residential	486	399	224	5	0	1,114
Commercial	7	3	1	0	0	11
Industrial	2	1	1	0	0	4
Other	2	0	0	0	0	2
Daviess						
Single Family	24,709	545	59	3	2,850	28,166
Other Residential	3,095	364	123	2	335	3,919
Commercial	256	8	1	0	39	304
Industrial	21	1	0	0	3	25
Other	23	0	0	0	3	26

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Fulton						
Single Family	24	364	819	509	681	2,397
Other Residential	2	22	50	47	227	348
Commercial	0	0	0	1	15	16
Industrial	0	0	0	0	3	3
Other	0	0	0	0	4	4
Graves						
Single Family	76	1,499	5,201	2,202	2,326	11,304
Other Residential	1	37	308	688	1,741	2,775
Commercial	0	0	8	21	49	78
Industrial	0	0	1	3	19	23
Other	0	0	1	2	10	13
Hancock						
Single Family	2,314	14	1	0	0	2,329
Other Residential	844	85	10	0	0	939
Commercial	8	0	0	0	0	8
Industrial	10	0	0	0	0	10
Other	1	0	0	0	0	1
Henderson						
Single Family	9,907	1,452	176	9	1,294	12,838
Other Residential	1,473	892	469	12	272	3,118
Commercial	74	31	13	1	22	141
Industrial	23	11	6	1	3	44
Other	10	3	1	0	4	18
Hickman						
Single Family	2	118	862	414	307	1,703
Other Residential	0	0	4	33	424	461
Commercial	0	0	0	0	5	5
Industrial	0	0	0	0	1	1
Other	0	0	0	0	4	4
Hopkins						
Single Family	11,326	1,518	186	11	818	13,859
Other Residential	1,647	1,219	670	17	190	3,743
Commercial	81	34	14	1	5	135
Industrial	14	7	4	0	0	25
Other	16	6	2	0	1	25
Livingston						
Single Family	1,078	1,067	583	85	109	2,922
Other Residential	206	255	453	368	106	1,388
Commercial	3	5	10	7	3	28
Industrial	1	0	1	1	0	3
Other	2	1	2	1	0	6

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Logan						
Single Family	8,039	50	3	0	0	8,092
Other Residential	1,987	187	23	0	0	2,197
Commercial	63	2	0	0	0	65
Industrial	18	1	0	0	0	19
Other	11	0	0	0	0	11
Lyon						
Single Family	2,175	386	46	2	59	2,668
Other Residential	492	394	219	5	34	1,144
Commercial	14	6	2	0	1	23
Industrial	0	0	0	0	0	0
Other	4	2	0	0	0	6
Marshall						
Single Family	164	2,569	5,461	1,244	1,115	10,553
Other Residential	2	42	495	1,072	1,350	2,961
Commercial	0	1	8	20	39	68
Industrial	0	0	1	2	5	8
Other	0	0	1	2	5	8
McCracken						
Single Family	11	705	7,951	6,619	5,431	20,717
Other Residential	0	26	371	873	3,032	4,302
Commercial	0	0	5	32	241	278
Industrial	0	0	0	1	8	9
Other	0	0	2	3	16	21
McLean						
Single Family	2,351	130	15	1	113	2,610
Other Residential	868	225	96	2	53	1,244
Commercial	11	2	1	0	1	15
Industrial	0	0	0	0	0	0
Other	3	0	0	0	0	3
Muhlenberg						
Single Family	8,250	52	3	0	256	8,561
Other Residential	2,791	272	34	0	78	3,175
Commercial	47	1	0	0	4	52
Industrial	4	0	0	0	1	5
Other	18	0	0	0	2	20
Ohio						
Single Family	6,020	38	3	0	0	6,061
Other Residential	2,357	230	28	0	0	2,615
Commercial	33	1	0	0	0	34
Industrial	6	0	0	0	0	6
Other	6	0	0	0	0	6

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Todd						
Single Family	3,359	21	1	0	0	3,381
Other Residential	986	99	12	0	0	1,097
Commercial	9	0	0	0	0	9
Industrial	5	0	0	0	0	5
Other	11	0	0	0	0	11
Trigg						
Single Family	4,171	559	68	3	0	4,801
Other Residential	637	514	287	7	0	1,445
Commercial	14	6	2	0	0	22
Industrial	9	4	3	0	0	16
Other	3	1	0	0	0	4
Union						
Single Family	2,664	547	64	4	1,092	4,371
Other Residential	414	334	186	5	313	1,252
Commercial	16	7	3	0	8	34
Industrial	3	1	1	0	1	6
Other	0	0	0	0	0	0
Webster						
Single Family	3,567	478	59	3	224	4,331
Other Residential	494	417	235	6	80	1,232
Commercial	10	4	2	0	1	17
Industrial	2	1	1	0	0	4
Other	4	1	0	0	0	5

Table 197: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Ballard	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
Caldwell	15	7	46.67	7	46.67	11	73.33	15	100.00	15	100.00
Calloway	378	2	0.53	2	0.53	10	2.65	110	29.10	212	56.08
Carlisle	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
Christian	592	282	47.64	286	48.31	436	73.65	578	97.64	585	98.82
Crittenden	48	23	47.92	23	47.92	35	72.92	47	97.92	47	97.92
Daviess	469	422	89.98	423	90.19	435	92.75	438	93.39	438	93.39
Fulton	70	0	0.00	0	0.00	2	2.86	28	40.00	45	64.29
Graves	106	0	0.00	0	0.00	0	0.00	0	0.00	2	1.89
Hancock	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
Henderson	205	73	35.61	74	36.10	113	55.12	150	73.17	152	74.15
Hickman	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
Hopkins	401	191	47.63	194	48.38	295	73.57	391	97.51	396	98.75
Livingston	26	12	46.15	12	46.15	19	73.08	25	96.15	26	100.00
Logan	92	89	96.74	89	96.74	91	98.91	92	100.00	92	100.00
Lyon	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
Marshall	563	0	0.00	0	0.00	0	0.00	0	0.00	1	0.18
McCracken	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
McLean	84	0	0.00	0	0.00	0	0.00	0	0.00	1	1.19
Muhlenberg	135	130	96.30	130	96.30	134	99.26	135	100.00	135	100.00
Ohio	49	47	95.92	47	95.92	49	100.00	49	100.00	49	100.00
Todd	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A
Trigg	25	12	48.00	12	48.00	18	72.00	24	96.00	25	100.00
Union	54	24	44.44	24	44.44	37	68.52	49	90.74	50	92.59
Webster	0	0	N/A	0	N/A	0	N/A	0	N/A	0	N/A

Table 198: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Ballard	2	0.00
Caldwell	2	51.90
Calloway	3	0.73
Carlisle	2	0.00
Christian	6	51.90
Crittenden	2	51.90
Daviess	2	81.60
Fulton	3	0.00
Graves	3	0.00
Hancock	3	94.10
Henderson	3	45.30
Hickman	2	0.00
Hopkins	7	51.90
Livingston	1	0.80
Logan	5	94.10
Lyon	2	47.00
Marshall	3	0.00
McCracken	4	0.00
McLean	2	51.90
Muhlenberg	3	94.10
Ohio	3	89.93
Todd	4	94.10
Trigg	2	51.90
Union	4	39.65
Webster	4	49.38

Table 199: School Functionality

Counties	Count	Functionality at Day 1 (%)
Ballard	7	0.00
Caldwell	6	51.90
Calloway	13	0.80
Carlisle	4	0.00
Christian	27	51.90
Crittenden	3	51.90
Daviess	45	80.67
Fulton	9	0.00
Graves	18	0.00
Hancock	4	94.10
Henderson	16	44.00
Hickman	3	0.00
Hopkins	23	51.59
Livingston	5	14.60
Logan	15	94.10
Lyon	5	47.00
Marshall	13	0.00
McCracken	28	0.00
McLean	6	64.83
Muhlenberg	12	94.10
Ohio	12	89.93
Todd	7	94.10
Trigg	5	51.90
Union	7	42.76
Webster	8	51.08

Table 200: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Ballard	10	0.00
Caldwell	3	51.90
Calloway	11	12.91
Carlisle	6	0.00
Christian	23	51.90
Crittenden	7	51.90
Daviess	17	78.29
Fulton	3	0.00
Graves	18	0.00
Hancock	4	94.10
Henderson	14	46.19
Hickman	5	0.00
Hopkins	18	51.52
Livingston	8	12.30
Logan	6	94.10
Lyon	4	47.00
Marshall	12	0.00
McCracken	9	0.00
McLean	8	76.71
Muhlenberg	8	92.54
Ohio	9	91.32
Todd	7	94.10
Trigg	11	51.90
Union	8	40.40
Webster	9	51.17

Table 201: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Ballard	92	22.21	31.44	41.11	69.63	94.55
Caldwell	70	78.28	93.85	95.95	99.38	99.88
Calloway	111	54.85	76.56	82.38	94.77	99.03
Carlisle	42	25.33	37.56	47.96	76.44	95.79
Christian	265	89.51	97.68	98.58	99.80	99.90
Crittenden	61	77.69	93.40	95.58	99.20	99.84
Daviess	338	92.83	98.53	99.03	99.59	99.84
Fulton	63	31.29	47.21	56.97	82.15	96.82
Graves	158	33.29	50.54	60.26	84.62	97.23
Hancock	85	99.70	99.90	99.90	99.90	99.90
Henderson	320	86.22	95.32	96.42	98.40	99.63
Hickman	43	28.77	43.93	54.51	81.69	96.68
Hopkins	255	89.92	97.75	98.59	99.74	99.88
Livingston	82	43.75	64.76	72.93	91.61	98.45
Logan	125	93.20	98.90	99.40	99.90	99.90
Lyon	62	66.78	87.10	91.10	98.48	99.68
Marshall	146	38.80	57.97	66.24	86.48	97.54
McCracken	251	24.67	36.00	45.71	73.31	95.23
McLean	53	93.00	98.70	99.20	99.73	99.87
Muhlenberg	177	93.16	98.86	99.36	99.87	99.89
Ohio	127	93.10	98.80	99.30	99.81	99.88
Todd	63	93.20	98.90	99.40	99.90	99.90
Trigg	71	78.40	94.00	96.10	99.50	99.90
Union	113	77.54	92.90	95.00	98.67	99.69
Webster	89	85.36	96.00	97.30	99.37	99.82

Table 202: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Ballard	3,395	99.41	99.26	98.76	0.00	0.00
Caldwell	5,431	0.00	0.00	0.00	0.00	0.00
Calloway	13,862	55.34	42.19	7.59	0.00	0.00
Carlisle	2,208	98.19	97.24	92.71	0.00	0.00
Christian	24,857	0.00	0.00	0.00	0.00	0.00
Crittenden	3,829	0.00	0.00	0.00	0.00	0.00
Daviess	36,033	34.44	20.03	0.02	0.00	0.00
Fulton	3,237	98.33	97.62	94.84	0.00	0.00
Graves	14,841	99.34	99.28	99.12	96.83	0.00
Hancock	3,215	0.00	0.00	0.00	0.00	0.00
Henderson	18,095	38.88	22.65	0.00	0.00	0.00
Hickman	2,188	97.71	96.66	92.37	0.00	0.00
Hopkins	18,820	61.06	51.14	23.07	0.00	0.00
Livingston	3,996	22.15	0.00	0.00	0.00	0.00
Logan	10,506	0.00	0.00	0.00	0.00	0.00
Lyon	2,898	0.10	0.00	0.00	0.00	0.00
Madison	27,152	0.00	0.00	0.00	0.00	0.00
Marshall	12,412	69.05	58.86	25.88	0.00	0.00
Mason	6,847	0.00	0.00	0.00	0.00	0.00
Muhlenberg	12,357	0.30	0.00	0.00	0.00	0.00
Ohio	8,899	0.00	0.00	0.00	0.00	0.00
Todd	4,569	0.00	0.00	0.00	0.00	0.00
Trigg	5,215	0.00	0.00	0.00	0.00	0.00
Union	5,710	97.93	97.48	96.09	0.00	0.00
Webster	5,560	27.09	2.55	0.00	0.00	0.00

Table 203: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Ballard	N/A	N/A	N/A	N/A	N/A	N/A
Caldwell	N/A	N/A	N/A	N/A	N/A	N/A
Calloway	N/A	N/A	N/A	N/A	N/A	N/A
Carlisle	N/A	N/A	N/A	N/A	N/A	N/A
Christian	2	0.50	0.38	0.11	0.01	0.00
Crittenden	1	0.20	0.42	0.31	0.07	0.01
Daviess	2	0.50	0.37	0.11	0.01	0.01
Fulton	N/A	N/A	N/A	N/A	N/A	N/A
Graves	N/A	N/A	N/A	N/A	N/A	N/A
Hancock	2	0.94	0.06	0.00	0.00	0.00
Henderson	1	0.50	0.37	0.11	0.01	0.01
Hickman	N/A	N/A	N/A	N/A	N/A	N/A
Hopkins	2	0.35	0.40	0.21	0.04	0.00
Livingston	3	0.02	0.13	0.36	0.32	0.18
Logan	2	0.50	0.38	0.11	0.01	0.00
Lyon	3	0.12	0.35	0.37	0.12	0.04
Marshall	3	0.02	0.13	0.35	0.32	0.18
McCracken	3	0.00	0.03	0.20	0.38	0.38
McLean	2	0.50	0.37	0.11	0.01	0.00
Muhlenberg	2	0.50	0.38	0.11	0.01	0.00
Ohio	3	0.50	0.37	0.11	0.01	0.00
Todd	1	0.50	0.38	0.11	0.01	0.00
Trigg	1	0.20	0.42	0.31	0.07	0.01
Union	N/A	N/A	N/A	N/A	N/A	N/A
Webster	3	0.29	0.40	0.24	0.05	0.03

Table 204: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Ballard	500	675	718
Caldwell	708	4	3
Calloway	1,129	143	229
Carlisle	376	968	384
Christian	1,615	9	2
Crittenden	694	4	1
Daviess	1,399	53	185
Fulton	442	941	459
Graves	1,318	1,200	1,780
Hancock	474	3	1
Henderson	1,203	50	177
Hickman	446	996	417
Hopkins	1,267	78	284
Livingston	571	65	73
Logan	1,271	7	2
Lyon	597	26	32
Madison	981	418	266
Marshall	997	1,447	1,180
Mason	519	14	45
Muhlenberg	1,193	17	43
Ohio	1,289	7	2
Todd	712	4	1
Trigg	1,044	6	1
Union	773	187	732
Webster	767	29	99

Table 205: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Ballard	3,395	95.58	87.22	67.01	26.10	0.09
Caldwell	5,431	0.00	0.00	0.00	0.00	0.00
Calloway	13,862	79.17	48.43	18.66	3.64	0.10
Carlisle	2,208	94.47	82.47	57.38	19.43	0.09
Christian	24,857	0.00	0.00	0.00	0.00	0.00
Crittenden	3,829	13.76	7.00	1.91	0.24	0.03
Daviess	36,033	0.00	0.00	0.00	0.00	0.00
Fulton	3,237	91.75	74.51	46.18	14.15	0.09
Graves	14,841	90.93	72.19	43.30	13.11	0.10
Hancock	3,215	0.00	0.00	0.00	0.00	0.00
Henderson	18,095	0.00	0.00	0.00	0.00	0.00
Hickman	2,188	93.19	78.02	49.82	15.08	0.09
Hopkins	18,820	0.00	0.00	0.00	0.00	0.00
Livingston	3,996	86.26	61.11	29.40	6.58	0.10
Logan	10,506	0.00	0.00	0.00	0.00	0.00
Lyon	2,898	56.04	28.54	7.94	1.04	0.07
Madison	27,152	0.00	0.00	0.00	0.00	0.00
Marshall	12,412	85.98	60.13	28.16	6.10	0.10
Mason	6,847	0.00	0.00	0.00	0.00	0.00
Muhlenberg	12,357	0.00	0.00	0.00	0.00	0.00
Ohio	8,899	0.00	0.00	0.00	0.00	0.00
Todd	4,569	0.00	0.00	0.00	0.00	0.00
Trigg	5,215	0.00	0.00	0.00	0.00	0.00
Union	5,710	0.00	0.00	0.00	0.00	0.00
Webster	5,560	0.00	0.00	0.00	0.00	0.00

Table 206: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Ballard	22	0.00	0.01	0.11	0.37	0.51
Caldwell	16	0.20	0.42	0.31	0.07	0.01
Calloway	40	0.03	0.19	0.38	0.23	0.16
Carlisle	16	0.00	0.02	0.18	0.41	0.39
Christian	83	0.43	0.39	0.16	0.02	0.00
Crittenden	11	0.18	0.41	0.33	0.08	0.01
Daviess	162	0.50	0.37	0.11	0.01	0.01
Fulton	15	0.00	0.06	0.25	0.39	0.29
Graves	57	0.01	0.06	0.28	0.39	0.27
Hancock	82	0.94	0.06	0.00	0.00	0.00
Henderson	165	0.36	0.38	0.19	0.03	0.03
Hickman	24	0.00	0.04	0.22	0.41	0.33
Hopkins	99	0.40	0.39	0.18	0.03	0.00
Livingston	51	0.02	0.13	0.36	0.32	0.17
Logan	45	0.50	0.38	0.11	0.01	0.00
Lyon	33	0.11	0.35	0.37	0.12	0.04
Marshall	125	0.01	0.10	0.32	0.31	0.26
McCracken	147	0.00	0.02	0.15	0.37	0.45
McLean	19	0.50	0.37	0.11	0.01	0.01
Muhlenberg	89	0.50	0.38	0.11	0.01	0.00
Ohio	102	0.50	0.37	0.11	0.01	0.00
Todd	20	0.50	0.38	0.11	0.01	0.00
Trigg	28	0.20	0.42	0.31	0.07	0.01
Union	51	0.19	0.41	0.30	0.06	0.03
Webster	59	0.36	0.39	0.20	0.03	0.02

Table 207: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Ballard	300	534	568
Caldwell	425	4	3
Calloway	678	113	181
Carlisle	225	765	303
Christian	969	7	2
Crittenden	417	3	1
Daviess	840	42	147
Fulton	265	744	363
Graves	791	949	1,408
Hancock	284	2	1
Henderson	722	40	140
Hickman	268	788	330
Hopkins	760	61	225
Livingston	343	52	58
Logan	763	5	1
Lyon	358	20	25
Madison	589	330	211
Marshall	598	1,145	934
Mason	311	11	36
Muhlenberg	716	13	34
Ohio	773	6	1
Todd	427	3	1
Trigg	627	5	1
Union	464	148	579
Webster	460	23	78

Table 208: Highway Bridge Damage

Counties	# of Bridges	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Ballard	25	0.33	0.10	0.07	0.12	0.38
Caldwell	84	0.93	0.02	0.01	0.00	0.04
Calloway	36	0.75	0.06	0.02	0.03	0.14
Carlisle	15	0.16	0.09	0.09	0.17	0.49
Christian	202	0.97	0.02	0.01	0.00	0.00
Crittenden	19	0.98	0.01	0.00	0.00	0.01
Daviess	233	0.86	0.02	0.01	0.10	0.01
Fulton	18	0.17	0.11	0.09	0.18	0.45
Graves	122	0.40	0.11	0.08	0.12	0.29
Hancock	64	0.98	0.01	0.00	0.00	0.00
Henderson	171	0.82	0.02	0.00	0.06	0.10
Hickman	22	0.23	0.11	0.12	0.19	0.36
Hopkins	207	0.89	0.03	0.01	0.03	0.04
Livingston	30	0.84	0.04	0.01	0.03	0.08
Logan	33	0.97	0.02	0.01	0.00	0.00
Lyon	49	0.94	0.05	0.00	0.01	0.00
Marshall	90	0.46	0.09	0.07	0.11	0.27
McCracken	80	0.32	0.08	0.07	0.17	0.37
McLean	64	0.85	0.02	0.01	0.11	0.01
Muhlenberg	127	0.91	0.02	0.01	0.06	0.00
Ohio	190	0.92	0.01	0.00	0.06	0.01
Todd	22	0.98	0.01	0.00	0.00	0.00
Trigg	38	0.97	0.01	0.00	0.00	0.01
Union	114	0.71	0.06	0.00	0.00	0.22
Webster	118	0.81	0.02	0.00	0.05	0.12

Table 209: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Ballard	25	43.66	48.30	51.16	53.08	61.64
Caldwell	84	94.87	95.56	95.75	95.87	96.34
Calloway	36	80.56	82.69	83.59	84.11	86.38
Carlisle	15	27.03	31.97	35.49	38.07	49.69
Christian	202	98.60	99.32	99.53	99.58	99.75
Crittenden	19	98.09	98.33	98.43	98.47	98.67
Daviess	233	87.79	88.35	88.68	89.62	94.92
Fulton	18	29.21	34.68	38.51	41.17	53.23
Graves	122	51.79	56.95	60.06	61.86	69.57
Hancock	64	99.11	99.51	99.67	99.70	99.81
Henderson	171	83.86	84.50	84.75	85.37	88.80
Hickman	22	35.71	41.92	46.60	49.32	61.11
Hopkins	207	92.05	93.13	93.49	93.84	95.61
Livingston	30	87.43	88.78	89.31	89.72	91.57
Logan	33	98.76	99.38	99.60	99.64	99.77
Lyon	49	97.83	99.09	99.24	99.32	99.66
Madison	90	55.47	59.77	62.42	64.12	71.63
Marshall	80	41.12	45.08	47.83	50.12	60.88
Mason	64	86.98	87.66	88.03	89.04	94.75
Muhlenberg	127	92.91	93.79	94.19	94.72	97.58
Ohio	190	92.99	93.50	93.75	94.28	97.17
Todd	22	99.00	99.44	99.63	99.66	99.79
Trigg	38	98.06	98.34	98.42	98.46	98.63
Union	114	76.04	77.63	77.82	78.15	79.80
Webster	118	83.04	83.59	83.83	84.39	87.47

Mississippi – New Madrid Seismic Zone Scenario

This earthquake impact assessment includes all 82 counties in the State of Mississippi. Mississippi is approximately 47,700 square miles and is bordered by Tennessee to the north, the Gulf of Mexico to the south, Alabama to the east, and Arkansas and Louisiana to the west. For the purposes of this analysis, 25 critical counties have been identified in the northern portion of the state where shaking is anticipated to be most intense. These 25 counties are the focus of much of the damage assessment included within this document.

- Alcorn
- Benton
- Bolivar
- Calhoun
- Chickasaw
- Coahoma
- Desoto
- Grenada
- Itawamba
- Lafayette
- Lee
- Marshall
- Monroe
- Panola
- Pontotoc
- Prentiss
- Quitman
- Sunflower
- Tallahatchie
- Tate
- Tippah
- Tishomingo
- Tunica
- Union
- Yalobusha

The scenario consists of a magnitude 7.7 (M_w7.7) earthquake along one segment of the NMSZ. The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS) for the middle fault in the proposed New Madrid Seismic Zone. Each fault line is presumed to consist of three fault segments; northeastern, central, and southwestern. The worst-case NMSZ scenario for the State of Mississippi employs an event in the southwest segment of the eastern fault. The location of this scenario event is illustrated in Figure 8 .For more information on the hazard utilized in this scenario please reference Appendix I.

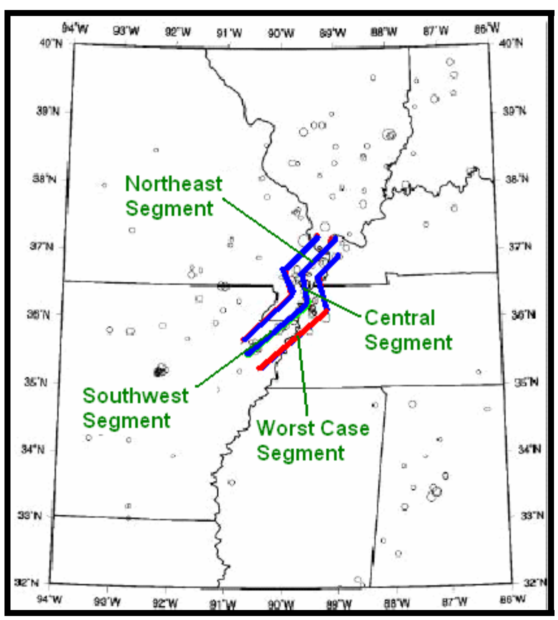

Figure 8: Scenario Fault Location for the State of Mississippi

The buildings in Mississippi are classified in two separate ways for damage estimates; by building use, termed "occupancy," and by structure type/material, termed "building type." The damage estimates shown indicate that less than 1% of the building stock in Mississippi experiences complete damage. This equates to roughly 7,300 completely damaged buildings in Mississippi. These completely damaged buildings are included in the roughly 39,000 at least moderately damaged buildings. Nearly 95% of all building collapses occurring to residential structures. In addition, about 89% of all at least moderate damage occurs in the 25 critical counties for Mississippi.

Table 210: Damage by General Occupancy Type for the State of Mississippi

General Occupancy Type Damage (State level)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	793,953	11,343	3,881
Other Residential	212,185	26,741	3,094
Commercial	8,062	705	190
Industrial	1,657	466	112
Other	1,478	127	23
Total	1,017,335	39,382	7,300

Table 211: Damage by General Occupancy Type for the 25 Critical Counties

General Occupancy Type Damage (25 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	213,381	10,858	3,881
Other Residential	55,294	23,214	3,094
Commercial	2,060	627	190
Industrial	944	445	112
Other	349	99	23
Total	272,028	35,243	7,300

Wood construction is the most prevalent building type in Mississippi and sustains the most cases of complete damage. Nearly 46% of all instances of all complete damage, which is roughly 3,300 buildings, are experienced by wood frame structures. Unreinforced masonry (URM) construction and mobile homes (MH) also show high frequencies of complete damage and account for nearly all non-wood construction damage of this type. Concrete, steel, and reinforced masonry construction types represent considerably fewer cases of complete damage.

Of the 984 fire stations in the state, 81 (more than 8%) are estimated to experience at least moderate damage. Approximately 8-9% of most other essential facility types (schools, hospitals, and police stations) each sustain at least moderate damage. The only emergency operation center expected to sustain this level of damage is located in Desoto County.

Table 212: Building Damage by Building Type for the State of Mississippi

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	703,568	50807	7,092	189	3,335
Steel	2,512	297	296	269	181
Concrete	906	102	84	63	30
Precast	955	104	113	78	40
Reinforced Masonry	494	39	36	21	12
Unreinforced Masonry	44,187	6104	3,553	1,531	764
Mobile Home	133,149	27429	16,731	9,326	2,938
Total	885,771	84,882	27,905	11,477	7,300

All non-functional facilities are located in the northern portion of the state. Of Mississippi's 123 hospitals, 89 are considered functional the day after the earthquake, and that number increases to 112 functional facilities after one week. Over 90% of all fire stations and police stations in Mississippi are estimated to remain functional the day after the earthquake, though all these functioning facilities are in the southern portion of the state. Most of Mississippi's northern counties are left without functioning facilities, and will likely experience diminished services in the immediate aftermath of an earthquake.

Table 213: Essential Facilities Damage & Functionality for the State of Mississippi[8]

Essential Facilities Damage & Functionality (State)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	123	11	2	89
Schools	1,281	110	10	1,130
EOCs	37	1	0	35
Police Stations	365	30	2	322
Fire Stations	984	81	3	856

[8] For Tables 213-223 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Table 214: Essential Facilities Damage & Functionality for the 25 Critical Counties

Essential Facilities Damage & Functionality (25 Critical Counties)				
Essential Facility Type	Total No. Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
Hospitals	27	11	2	0
Schools	353	110	10	202
EOCs	10	1	0	8
Police Stations	121	30	2	78
Fire Stations	294	81	3	166

Table 215: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	5,043	73	0	4,978
Remaining Counties	11,893	0	0	11,893
Total State	16,936	73	0	16,871

Table 216: Airport Damage Assessments

Airport Damage Assessments				
	Total No. Of Airport	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	80	5	0	80
Remaining Counties	176	0	0	176
Total State	256	5	0	256

As is the case with essential facilities, transportation lifelines also incur the most severe damage in northern Mississippi counties Roughly 75 of the 16,900 bridges, or less than 1% of all bridges, are estimated to incur at least moderate damage. Highway road segments connecting these damaged bridges are expected to incur slightly less damage than the bridges themselves, even in the counties with the most severe shaking. Highway segments are most generally defined as a section of highway between two end nodes. These end nodes are frequently highway bridges. At least moderate damage to highway bridges is characterized by moderate shear (diagonal) cracking of columns, spalling of cover concrete and shear keys, abutment movement less than two-inches, extensive cracking to shear keys, bent connection bolts, and moderate settlement of the bridge approaches. Furthermore, one port and five airports reach the at least moderate damage state and follow roughly the same damage distribution throughout the state as highway bridges. At least moderate damage to port facilities includes considerable ground settlement, derailment of port equipment, and damage to structural members. For airports, at least moderate damage is defined in the same manner as damage to other building types discussed previously.

Table 217: Transportation System Damage for the State of Mississippi

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	2,425	0	0	2,425
	Bridges	16,936	73	0	16,871
	Tunnels	0	0	0	0
Railways	Segments	2,376	0	0	2,376
	Bridges	63	0	0	63
	Tunnels	1	0	0	1
	Facilities	76	0	0	76
Bus	Facilities	40	0	0	40
Light Rail	Segments	0	0	0	0
	Bridges	0	0	0	0
	Facilities	0	0	0	0
Ferry	Facilities	2	2	2	0
Port	Facilities	222	1	0	222
Airport	Facilities	256	5	0	256
	Runways	205	0	0	205

Table 218: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
25 Critical Counties	3	0	0	3
Remaining Counties	14	0	0	14
Total State	17	0	0	17

Table 219: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
25 Critical Counties	630	102	0	347
Remaining Counties	2,450	0	0	2,450
Total State	3,080	102	0	2,797

Utility lifelines show similar damage and functionality estimates to those of the transportation systems. Over 100 waste water and nearly 300 communication facilities incur at least moderate damage, while 24 electric power facilities reach the same damage state. There are no potable water facilities in the counties with the most intense shaking, and as a result, no potable water facilities are expected to reach the at least moderate damage. About 12% of all natural gas facilities in the critical counties incur at least moderate damage.

Table 220: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
25 Critical Counties	98	12	0	86
Remaining Counties	317	0	0	317
Total State	415	12	0	403

Table 221: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
25 Critical Counties	6	1	0	5
Remaining Counties	99	0	0	99
Total State	105	1	0	104

Table 222: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	128	24	0	80
Remaining Counties	620	0	0	620
Total State	748	24	0	700

Table 223: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
25 Critical Counties	2,553	290	0	2,553
Remaining Counties	6,663	0	0	6,663
Total State	9,216	290	0	9,216

Pipeline damage is estimated for local potable water, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not included in the HAZUS-MH MR2 default inventory, called local inventory in HAZUS-MH MR2, though regional oil pipelines are added to provide damage estimates for these major oil transmission lines. These oil pipelines are composed of major crude oil and refined product lines only. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at roughly 2,700 and 2,985, respectively. Local natural gas lines, however; show the greatest break and leak rates per length of pipe at

roughly 0.059 leaks/mile (1 leak every 17 miles) or 0.054 breaks/mile (roughly 1 break every 18.5 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of 2,583 leaks and 2,444 breaks over the combined length of 52,653 miles of natural gas pipeline.

Potable water service is cut off to nearly 42,000 residences the day after the scenario earthquake. This is reduced to roughly 40,000 residences within a week, with all service restored after three months. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program. This period of time without water prevents thousands of people from remaining in their homes in the weeks and months following the earthquake. Electric power service shows similar trends, with over 32,600 residences without electric power the day after the earthquake, or over 3% of all state residences. Even a month after the earthquake, nearly 1,300 residences are still without power. All electric power lines in Mississippi are presumed to be above ground and less likely to incur damage from moderate ground shaking, unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation

Table 224: Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	106,188	2,985	2,700
Waste Water - Local	63,698	2,361	2,136
Natural Gas - Regional	10,188	59	161
Natural Gas - Local	42,465	2,524	2,283
Oil - Regional	3,488	8	16

Table 225: Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	1,046,434	41,790	40,256	39,752	28,749	0
Electric Power		32,601	18,416	6,452	1,276	44

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county. The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as

discussed in footnote (8) and employed in the preceding damage tables for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Desoto County, Mississippi – 204 Highway Bridges
  - Estimation procedure according to footnote 8:
    - Summation of individual facilities after that facility is deemed 'damaged' or 'undamaged' based on 50% or greater damage likelihood requirement estimates **25 at least moderately damaged highway bridges**
  - Estimation procedure according to topic damage tables in this appendix:
    - To determine the percentage of waste water facilities in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of facilities in that county
    - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **56 at least moderately damaged highway bridges**

In the case of Desoto County, Mississippi, the topic damage tables in this appendix provide a higher estimate of damage as opposed to the facility-by-facility damage summation detailed in footnote (8). Though not illustrated here, other counties in Mississippi are estimated to incur less damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged highway bridges for the 25 critical counties in Mississippi shows the following:

- Total number of at least moderately damaged highway bridges according to the HAZUS-MH MR2 procedure for averaging damage at the county level
  - **300 at least moderately damaged highway bridges**
- Total number of at least moderately damaged highway bridges according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
  - **73 at least moderately damaged highway bridges**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces greater damage when summed for the 25 critical counties. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix. The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Mississippi. There tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage levels for a county.

Table 226: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Alcorn						
Single Family	8,816	2,152	247	28	5	11,248
Other Residential	962	763	613	243	38	2,619
Commercial	66	29	12	1	0	108
Industrial	14	7	5	1	0	27
Other	4	2	1	0	0	7
Benton						
Single Family	1,120	1,023	209	41	30	2,423
Other Residential	8	67	278	285	53	691
Commercial	0	1	3	2	1	7
Industrial	0	0	0	0	0	0
Other	0	0	0	0	0	0
Bolivar						
Single Family	8,309	968	75	3	0	9,355
Other Residential	907	606	393	195	35	2,136
Commercial	68	32	15	4	1	120
Industrial	3	1	1	0	0	5
Other	10	4	2	1	0	17
Calhoun						
Single Family	4,301	501	39	1	0	4,842
Other Residential	532	425	237	6	0	1,200
Commercial	16	7	3	0	0	26
Industrial	14	6	3	0	0	23
Other	3	1	0	0	0	4
Chickasaw						
Single Family	4,295	500	39	1	0	4,835
Other Residential	939	758	424	10	0	2,131
Commercial	28	12	5	0	0	45
Industrial	11	5	3	0	0	19
Other	8	3	1	0	0	12
Coahoma						
Single Family	6,613	770	60	2	0	7,445
Other Residential	436	221	231	342	63	1,293
Commercial	20	20	18	13	4	75
Industrial	1	1	2	3	1	8
Other	3	2	1	1	0	7
Desoto						
Single Family	13,432	15,658	4,780	743	2,713	37,326
Other Residential	128	240	649	1,091	1,320	3,428
Commercial	1	10	67	107	130	315
Industrial	0	2	12	28	49	91
Other	4	5	8	10	13	40

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Grenada						
Single Family	6,070	707	55	2	0	6,834
Other Residential	629	449	315	204	37	1,634
Commercial	49	22	10	2	1	84
Industrial	17	9	6	2	0	34
Other	4	2	1	0	0	7
Itawamba						
Single Family	6,357	740	58	2	0	7,157
Other Residential	906	761	428	10	0	2,105
Commercial	15	6	3	0	0	24
Industrial	2	1	0	0	0	3
Other	17	6	2	0	0	25
Lafayette						
Single Family	5,322	3,135	581	103	21	9,162
Other Residential	784	850	1,123	854	141	3,752
Commercial	4	20	52	37	9	122
Industrial	5	20	111	155	46	337
Other	2	3	8	6	1	20
Lee						
Single Family	20,288	2,363	184	7	0	22,842
Other Residential	2,671	1,805	974	24	0	5,474
Commercial	312	134	56	4	0	506
Industrial	99	46	25	2	0	172
Other	40	14	5	0	0	59
Marshall						
Single Family	3,915	3,575	728	142	158	8,518
Other Residential	72	374	1,437	1,466	295	3,644
Commercial	1	6	16	12	4	39
Industrial	0	1	4	6	2	13
Other	2	4	6	5	1	18
Monroe						
Single Family	10,075	1,174	91	3	0	11,343
Other Residential	1,522	1,190	661	16	0	3,389
Commercial	37	16	6	0	0	59
Industrial	11	5	3	0	0	19
Other	7	2	1	0	0	10
Panola						
Single Family	5,081	2,231	409	72	15	7,808
Other Residential	301	552	1,583	1,746	293	4,475
Commercial	18	21	24	17	5	85
Industrial	2	2	5	6	2	17
Other	4	3	4	3	1	15

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Pontotoc						
Single Family	6,784	864	67	2	0	7,717
Other Residential	1,059	860	481	12	0	2,412
Commercial	27	12	5	0	0	44
Industrial	18	8	4	0	0	30
Other	5	2	1	0	0	8
Prentiss						
Single Family	6,380	1,072	84	3	0	7,539
Other Residential	812	626	345	8	0	1,791
Commercial	27	12	5	0	0	44
Industrial	7	3	2	0	0	12
Other	9	4	1	0	0	14
Quitman						
Single Family	2,250	262	20	1	0	2,533
Other Residential	112	112	141	219	40	624
Commercial	2	2	2	1	0	7
Industrial	0	0	0	0	0	0
Other	2	1	1	1	0	5
Sunflower						
Single Family	6,748	618	48	2	0	7,416
Other Residential	383	185	120	70	13	771
Commercial	45	16	7	1	0	69
Industrial	6	2	1	0	0	9
Other	9	4	3	2	0	18
Tallahatchie						
Single Family	3,022	352	27	1	0	3,402
Other Residential	221	244	312	485	90	1,352
Commercial	5	5	5	3	1	19
Industrial	0	0	1	0	0	1
Other	5	3	3	2	1	14
Tate						
Single Family	3,050	2,785	567	110	443	6,955
Other Residential	87	257	831	837	238	2,250
Commercial	1	7	20	14	10	52
Industrial	0	2	8	8	7	25
Other	1	2	5	4	3	15
Tippah						
Single Family	3,025	2,762	561	104	22	6,474
Other Residential	36	179	681	693	113	1,702
Commercial	1	4	11	8	2	26
Industrial	1	4	14	15	4	38
Other	1	1	2	2	0	6

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Tishomingo						
Single Family	5,900	948	74	3	0	6,925
Other Residential	745	596	332	8	0	1,681
Commercial	25	11	5	0	0	41
Industrial	9	4	2	0	0	15
Other	9	3	1	0	0	13
Tunica						
Single Family	630	576	117	22	454	1,799
Other Residential	25	78	257	259	263	882
Commercial	1	9	23	17	22	72
Industrial	0	0	0	1	1	2
Other	0	1	2	2	3	8
Union						
Single Family	5,647	1,757	262	41	20	7,727
Other Residential	605	514	575	357	62	2,113
Commercial	34	16	8	2	0	60
Industrial	26	12	6	0	0	44
Other	4	2	1	0	0	7
Yalobusha						
Single Family	3,260	459	36	1	0	3,756
Other Residential	770	622	345	8	0	1,745
Commercial	7	3	1	0	0	11
Industrial	0	0	0	0	0	0
Other	0	0	0	0	0	0

Table 227: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Alcorn	165	78	47.30	79	47.90	121	73.30	161	97.60	163	98.80
Benton	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Bolivar	155	74	47.70	75	48.30	114	73.60	151	97.60	153	98.80
Calhoun	30	14	47.70	14	48.30	22	73.60	29	97.60	30	98.80
Chickasaw	84	40	47.70	41	48.30	62	73.60	82	97.60	83	98.80
Coahoma	195	33	17.00	34	17.50	78	39.80	169	86.60	182	93.20
Desoto	246	0	0	0	0	0	0	4.92	2	34.194	13.9
Grenada	156	74	47.70	75	48.30	115	73.60	152	97.60	154	98.80
Itawamba	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lafayette	204	1	0.40	1	0.50	6	2.70	62	30.20	119	58.10
Lee	50	24	47.70	24	48.30	37	73.60	49	97.60	49	98.80
Marshall	40	0	0.40	0	0.50	1	2.70	12	29.90	23	57.60
Monroe	144	69	47.70	70	48.30	106	73.60	141	97.60	142	98.80
Panola	182	16	8.70	16	9.00	39	21.25	106	58.40	138	75.65
Pontotoc	102	49	47.70	49	48.30	75	73.60	100	97.60	101	98.80
Prentiss	114	54	47.30	55	47.90	84	73.30	111	97.60	113	98.80
Quitman	36	6	17.00	6	17.50	14	39.80	31	86.60	34	93.20
Sunflower	160	76	47.70	77	48.30	118	73.60	156	97.60	158	98.80
Tallahatchie	77	13	17.00	13	17.50	31	39.80	67	86.60	72	93.20
Tate	76	0	0.30	0	0.30	2	2.00	17	22.60	33	43.60
Tippah	110	0	0.40	1	0.50	3	2.70	33	30.20	64	58.10
Tishomingo	48	23	47.30	23	47.90	35	73.30	47	97.60	47	98.80
Tunica	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Union	200	95	47.30	96	47.90	147	73.30	195	97.60	198	98.80
Yalobusha	85	40	47.30	41	47.90	62	73.30	83	97.60	84	98.80

* Note: Discrepancies between the number of hospital beds and the percentage of beds may occur due to rounding.

Table 228: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Alcorn	2	47.00
Benton	2	0.80
Bolivar	13	51.90
Calhoun	5	51.90
Chickasaw	4	51.90
Coahoma	7	51.90
Desoto	6	0.47
Grenada	2	51.90
Itawamba	4	51.90
Lafayette	3	0.90
Lee	7	51.90
Marshall	4	0.80
Monroe	5	51.90
Panola	6	9.33
Pontotoc	3	51.90
Prentiss	4	49.45
Quitman	5	51.90
Sunflower	8	67.73
Tallahatchie	7	51.90
Tate	4	0.80
Tippah	4	0.88
Tishomingo	6	49.45
Tunica	2	0.60
Union	4	47.00
Yalobusha	4	49.45

Table 229: School Functionality

Counties	Count	Functionality at Day 1 (%)
Alcorn	17	38.86
Benton	5	0.80
Bolivar	25	51.90
Calhoun	8	51.90
Chickasaw	9	51.90
Coahoma	23	51.90
Desoto	35	0.43
Grenada	7	51.90
Itawamba	9	51.90
Lafayette	15	17.36
Lee	32	51.90
Marshall	16	0.80
Monroe	19	51.90
Panola	15	28.08
Pontotoc	13	51.90
Prentiss	15	48.75
Quitman	5	51.90
Sunflower	24	61.07
Tallahatchie	7	51.90
Tate	13	0.75
Tippah	12	0.89
Tishomingo	9	49.72
Tunica	6	0.60
Union	9	32.12
Yalobusha	5	48.96

Table 230: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Alcorn	15	37.78
Benton	6	0.80
Bolivar	14	51.90
Calhoun	8	51.90
Chickasaw	7	51.90
Coahoma	11	51.90
Desoto	19	0.53
Grenada	10	51.90
Itawamba	12	51.90
Lafayette	16	18.18
Lee	22	51.90
Marshall	9	0.80
Monroe	22	51.90
Panola	12	13.62
Pontotoc	12	50.68
Prentiss	14	48.05
Quitman	5	51.90
Sunflower	7	63.96
Tallahatchie	14	51.90
Tate	12	0.78
Tippah	9	0.88
Tishomingo	16	49.14
Tunica	2	0.60
Union	13	42.13
Yalobusha	7	51.20

Table 231: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Alcorn	172	81.93	95.17	96.89	99.60	99.90
Benton	23	78.40	94.00	96.10	99.50	99.90
Bolivar	207	93.20	98.90	99.40	99.90	99.90
Calhoun	66	93.20	98.90	99.40	99.90	99.90
Chickasaw	78	93.20	98.90	99.40	99.90	99.90
Coahoma	121	91.45	98.29	98.97	99.82	99.89
Desoto	250	61.43	82.88	87.71	97.35	99.49
Grenada	74	93.20	98.90	99.40	99.90	99.90
Itawamba	55	93.20	98.90	99.40	99.90	99.90
Lafayette	99	78.40	94.00	96.10	99.50	99.90
Lee	219	93.22	98.90	99.40	99.90	99.90
Marshall	114	75.16	92.04	94.63	99.16	99.83
Monroe	186	93.21	98.90	99.40	99.90	99.90
Panola	112	78.36	93.95	96.05	99.46	99.89
Pontotoc	70	93.20	98.90	99.40	99.90	99.90
Prentiss	45	93.20	98.90	99.40	99.90	99.90
Quitman	60	88.27	97.27	98.30	99.77	99.90
Sunflower	128	95.62	99.27	99.58	99.90	99.90
Tallahatchie	60	93.20	98.90	99.40	99.90	99.90
Tate	69	75.31	91.77	94.26	98.68	99.74
Tippah	55	78.47	94.00	96.10	99.50	99.90
Tishomingo	65	93.22	98.90	99.40	99.90	99.90
Tunica	117	74.39	89.06	91.16	95.68	99.15
Union	73	85.09	96.22	97.59	99.68	99.90
Yalobusha	35	89.39	97.64	98.55	99.80	99.90

Table 232: Households without Potable Water Service

Counties	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
Alcorn	14,224	0	0	0	0	0
Benton	2,999	0	0	0	0	0
Bolivar	13,776	0	0	0	0	0
Calhoun	6,019	0	0	0	0	0
Chickasaw	7,253	0	0	0	0	0
Coahoma	10,553	0	0	0	0	0
Desoto	38,792	37,257	37,066	36,588	26,460	0
Grenada	8,820	0	0	0	0	0
Itawamba	8,773	0	0	0	0	0
Lafayette	14,373	0	0	0	0	0
Lee	29,200	0	0	0	0	0
Marshall	12,163	151	0	0	0	0
Monroe	14,603	0	0	0	0	0
Panola	12,232	5	0	0	0	0
Pontotoc	10,097	0	0	0	0	0
Prentiss	9,821	0	0	0	0	0
Quitman	3,565	0	0	0	0	0
Sunflower	9,637	0	0	0	0	0
Tallahatchie	5,263	0	0	0	0	0
Tate	8,850	1,178	1	0	0	0
Tippah	8,108	0	0	0	0	0
Tishomingo	7,917	0	0	0	0	0
Tunica	3,258	3,199	3,189	3,164	2,289	0
Union	9,786	0	0	0	0	0
Yalobusha	5,260	0	0	0	0	0

Table 233: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Alcorn	1	19.73%	42.20%	30.82%	6.56%	0.67%
Benton	0	N/A	N/A	N/A	N/A	N/A
Bolivar	0	N/A	N/A	N/A	N/A	N/A
Calhoun	0	N/A	N/A	N/A	N/A	N/A
Chickasaw	0	N/A	N/A	N/A	N/A	N/A
Coahoma	0	N/A	N/A	N/A	N/A	N/A
Desoto	0	N/A	N/A	N/A	N/A	N/A
Grenada	0	N/A	N/A	N/A	N/A	N/A
Itawamba	1	50.00%	37.59%	11.35%	0.98%	0.06%
Lafayette	0	N/A	N/A	N/A	N/A	N/A
Lee	0	N/A	N/A	N/A	N/A	N/A
Marshall	0	N/A	N/A	N/A	N/A	N/A
Monroe	0	N/A	N/A	N/A	N/A	N/A
Panola	0	N/A	N/A	N/A	N/A	N/A
Pontotoc	0	N/A	N/A	N/A	N/A	N/A
Prentiss	0	N/A	N/A	N/A	N/A	N/A
Quitman	0	N/A	N/A	N/A	N/A	N/A
Sunflower	0	N/A	N/A	N/A	N/A	N/A
Tallahatchie	0	N/A	N/A	N/A	N/A	N/A
Tate	0	N/A	N/A	N/A	N/A	N/A
Tippah	0	N/A	N/A	N/A	N/A	N/A
Tishomingo	1	50.00%	37.59%	11.35%	0.98%	0.06%
Tunica	0	N/A	N/A	N/A	N/A	N/A
Union	0	N/A	N/A	N/A	N/A	N/A
Yalobusha	0	N/A	N/A	N/A	N/A	N/A

Table 234: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Alcorn	1,071	39	10
Benton	789	36	16
Bolivar	2,273	98	24
Calhoun	994	43	11
Chickasaw	891	38	10
Coahoma	1,724	131	33
Desoto	1,523	671	1,117
Grenada	972	42	10
Itawamba	1,174	6	2
Lafayette	1,230	53	13
Lee	1,472	49	12
Marshall	1,396	142	58
Monroe	1,651	36	9
Panola	1,584	156	39
Pontotoc	1,025	44	11
Prentiss	997	19	5
Quitman	690	59	15
Sunflower	2,010	66	16
Tallahatchie	1,661	71	18
Tate	888	92	81
Tippah	975	42	10
Tishomingo	1,122	48	12
Tunica	1,032	384	1,011
Union	908	40	12
Yalobusha	1,001	43	11

Table 235: Households without Electric Power Service

Counties	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
Alcorn	14,224	0	0	0	0	0
Benton	2,999	0	0	0	0	0
Bolivar	13,776	0	0	0	0	0
Calhoun	6,019	0	0	0	0	0
Chickasaw	7,253	0	0	0	0	0
Coahoma	10,553	0	0	0	0	0
Desoto	38,792	29,217	16,692	5,972	1,213	39
Grenada	8,820	0	0	0	0	0
Itawamba	8,773	0	0	0	0	0
Lafayette	14,373	0	0	0	0	0
Lee	29,200	0	0	0	0	0
Marshall	12,163	1,930	983	274	36	3
Monroe	14,603	0	0	0	0	0
Panola	12,232	0	0	0	0	0
Pontotoc	10,097	0	0	0	0	0
Prentiss	9,821	0	0	0	0	0
Quitman	3,565	0	0	0	0	0
Sunflower	9,637	0	0	0	0	0
Tallahatchie	5,263	0	0	0	0	0
Tate	8,850	1,454	741	206	27	2
Tippah	8,108	0	0	0	0	0
Tishomingo	7,917	0	0	0	0	0
Tunica	3,258	0	0	0	0	0
Union	9,786	0	0	0	0	0
Yalobusha	5,260	0	0	0	0	0

Table 236: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Alcorn	21	21.17%	41.98%	29.89%	6.29%	0.64%
Benton	8	19.73%	42.20%	30.82%	6.56%	0.67%
Bolivar	37	50.00%	37.59%	11.35%	0.98%	0.06%
Calhoun	13	50.00%	37.59%	11.35%	0.98%	0.06%
Chickasaw	29	50.0%	37.6%	11.4%	1.0%	0.1%
Coahoma	28	44.59%	38.41%	14.83%	1.98%	0.17%
Desoto	90	7.48%	30.20%	40.69%	16.73%	4.88%
Grenada	31	50.00%	37.59%	11.35%	0.98%	0.06%
Itawamba	18	50.00%	37.59%	11.35%	0.98%	0.06%
Lafayette	26	19.73%	42.20%	30.82%	6.56%	0.67%
Lee	49	50.00%	37.59%	11.35%	0.98%	0.06%
Marshall	24	17.4%	40.2%	32.8%	8.3%	1.3%
Monroe	31	50.00%	37.59%	11.35%	0.98%	0.06%
Panola	38	19.73%	42.20%	30.82%	6.56%	0.67%
Pontotoc	25	50.0%	37.6%	11.4%	1.0%	0.1%
Prentiss	13	50.00%	37.59%	11.35%	0.98%	0.06%
Quitman	6	24.78%	41.43%	27.58%	5.63%	0.57%
Sunflower	24	59.7%	30.4%	9.0%	0.8%	0.0%
Tallahatchie	12	50.00%	37.59%	11.35%	0.98%	0.06%
Tate	27	16.03%	38.17%	32.36%	8.53%	4.89%
Tippah	17	19.73%	42.20%	30.82%	6.56%	0.67%
Tishomingo	25	50.00%	37.59%	11.35%	0.98%	0.06%
Tunica	16	18.35%	39.26%	28.68%	6.10%	7.59%
Union	12	39.91%	39.13%	17.84%	2.84%	0.26%
Yalobusha	10	40.92%	38.97%	17.19%	2.65%	0.24%

Table 237: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Alcorn	1,035	31	8
Benton	763	28	13
Bolivar	2,196	77	19
Calhoun	960	34	8
Chickasaw	861	30	8
Coahoma	1,666	104	26
Desoto	1,472	531	883
Grenada	939	33	8
Itawamba	1,134	5	1
Lafayette	1,189	42	10
Lee	1,422	39	10
Marshall	1,349	112	46
Monroe	1,596	28	7
Panola	1,531	124	31
Pontotoc	991	35	9
Prentiss	963	15	4
Quitman	667	47	12
Sunflower	1,942	52	13
Tallahatchie	1,604	56	14
Tate	858	72	64
Tippah	943	33	8
Tishomingo	1,085	38	10
Tunica	997	304	800
Union	877	31	9
Yalobusha	967	34	9

Table 238: Highway Bridge Damage

Counties	# of Bridges	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Alcorn	234	90.34%	7.05%	1.24%	1.00%	0.36%
Benton	120	85.82%	5.20%	3.03%	3.40%	2.53%
Bolivar	286	97.01%	1.57%	0.67%	0.55%	0.18%
Calhoun	224	97.30%	2.03%	0.42%	0.21%	0.03%
Chickasaw	231	97.41%	1.94%	0.40%	0.20%	0.03%
Coahoma	112	85.66%	6.16%	3.39%	3.33%	1.43%
Desoto	204	62.86%	9.83%	6.02%	8.30%	12.97%
Grenada	171	88.68%	4.57%	2.63%	2.84%	1.26%
Itawamba	240	97.32%	1.99%	0.43%	0.22%	0.03%
Lafayette	263	89.19%	6.00%	1.74%	1.61%	1.43%
Lee	377	97.32%	1.95%	0.45%	0.23%	0.03%
Marshall	256	79.93%	6.96%	3.78%	4.36%	4.95%
Monroe	289	98.79%	0.90%	0.19%	0.10%	0.01%
Panola	251	82.63%	7.29%	4.01%	4.17%	1.87%
Pontotoc	164	96.21%	3.24%	0.34%	0.17%	0.02%
Prentiss	206	94.14%	5.16%	0.43%	0.22%	0.03%
Quitman	117	70.15%	11.43%	7.01%	7.73%	3.66%
Sunflower	189	94.24%	2.78%	1.28%	1.20%	0.47%
Tallahatchie	155	79.79%	7.92%	4.77%	5.23%	2.27%
Tate	157	72.14%	8.03%	4.43%	5.62%	9.75%
Tippah	175	88.18%	5.26%	2.77%	2.71%	1.06%
Tishomingo	138	95.24%	4.22%	0.33%	0.17%	0.02%
Tunica	63	65.80%	4.52%	2.60%	2.57%	24.48%
Union	242	89.20%	5.94%	1.88%	1.81%	1.14%
Yalobusha	179	96.68%	2.53%	0.49%	0.25%	0.03%

Table 239: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Alcorn	234	95.97	98.09	98.56	98.72	99.23
Benton	120	90.70	92.91	94.12	94.57	96.43
Bolivar	286	98.33	98.92	99.20	99.27	99.54
Calhoun	224	98.90	99.52	99.68	99.71	99.80
Chickasaw	231	98.94	99.53	99.69	99.71	99.81
Coahoma	112	91.32	93.88	95.23	95.69	97.42
Desoto	204	72.46	76.68	79.08	80.27	85.28
Grenada	171	92.93	94.84	95.88	96.27	97.75
Itawamba	240	98.90	99.51	99.68	99.70	99.80
Lafayette	263	94.23	96.23	96.91	97.15	98.04
Lee	377	98.87	99.48	99.65	99.69	99.80
Marshall	256	86.43	89.30	90.80	91.41	93.90
Monroe	289	99.46	99.73	99.80	99.81	99.86
Panola	251	89.36	92.39	93.97	94.55	96.73
Pontotoc	164	98.69	99.59	99.72	99.74	99.82
Prentiss	206	98.10	99.50	99.66	99.70	99.80
Quitman	117	81.01	85.94	88.69	89.77	93.84
Sunflower	189	96.69	97.76	98.27	98.43	99.05
Tallahatchie	155	87.25	90.65	92.54	93.25	95.98
Tate	157	79.78	83.10	84.87	85.70	89.13
Tippah	175	92.95	95.11	96.21	96.57	97.97
Tishomingo	138	98.47	99.60	99.72	99.75	99.83
Tunica	63	70.46	72.36	73.42	74.09	77.00
Union	242	94.23	96.27	97.00	97.26	98.23
Yalobusha	179	98.68	99.44	99.64	99.67	99.79

Missouri – New Madrid Seismic Zone Scenario

This earthquake impact assessment includes the City of St. Louis and all 114 counties in the State of Missouri. Missouri is approximately 70,000 square miles and is bordered by Iowa to the north; Arkansas to the south; Illinois, Kentucky, and Tennessee to the east; and Nebraska, Kansas, and Oklahoma to the west. For the purposes of this analysis, 46 critical counties have been identified in the southeastern portion of the state where shaking is anticipated to be most intense. These 46 counties are the focus of much of the damage assessment included within this document.

- Audrain
- Bollinger
- Boone
- Butler
- Callaway
- Cape Girardeau
- Carter
- Cole
- Crawford
- Dent
- Douglas
- Dunklin
- Franklin
- Gasconade
- Howell
- Iron
- Jefferson
- Lincoln
- Madison
- Maries
- Miller
- Mississippi
- Montgomery
- New Madrid
- Oregon
- Osage
- Ozark
- Pemiscot
- Perry
- Phelps
- Pike
- Pulaski
- Reynolds
- Ripley
- St. Charles
- Ste. Genevieve
- St. Francois
- St. Louis
- St. Louis City
- Scott
- Shannon
- Stoddard
- Texas
- Warren
- Washington
- Wayne

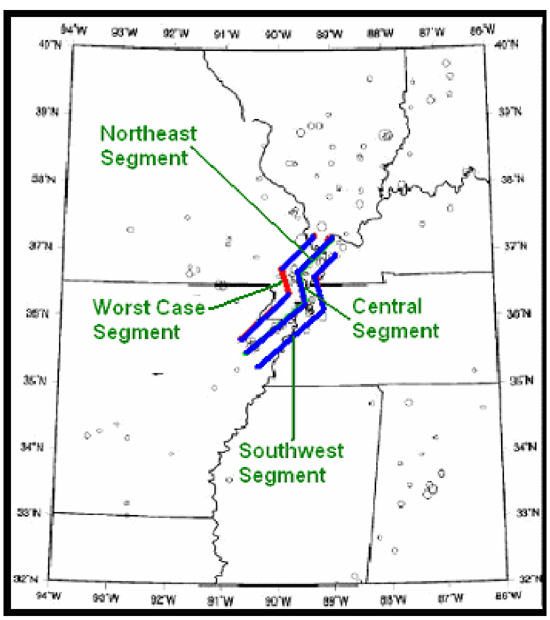

Figure 9: Scenario Fault Location for the State of Missouri

The earthquake impact assessment for the State of Missouri employs one scenario event along the New Madrid Fault. The scenario consists of a magnitude 7.7 (M_w7.7) earthquake event along the central segment of the presumed New Madrid Fault system.

The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS) for the middle fault in the proposed New Madrid Seismic Zone (NMSZ). Each fault line is presumed to consist of three fault segments; northern, central and southern. The worst-case scenario for the State of Missouri, the critical counties in particular, is an event on the western fault line in the central segment. The location of this scenario event is illustrated in Figure 9 . For more information on the hazard utilized in this scenario please reference Appendix I.

The NMSZ scenario produces thousands of damaged buildings in the State of Missouri. The damage estimates shown indicate that nearly 85,000 buildings in Missouri experience at least moderate damage, of which 37,000 of these buildings experience complete damage. Nearly 98% of all at least moderate damage and complete damage occurs to residential structures. Additionally, about 98% of all at least moderate damage occurs in the 46 critical counties.

Table 240: Damage by General Occupancy Type for the State of Missouri

General Occupancy Type Damage (State level)			
General Occupancy Type	Total No. Buildings	At Least Moderate Damage	Complete Damage
Single Family	1,472,235	55,807	23,860
Other Residential	272,089	26,748	12,179
Commercial	20,433	1,560	651
Industrial	2,872	226	80
Other	2,916	226	121
Total	1,770,545	84,567	36,891

Table 241: Damage by General Occupancy Type for the 46 Critical Counties

General Occupancy Type Damage (46 Critical Counties)			
General Occupancy Type	Total No. Buildings	At Least Moderate Damage	Complete Damage
Single Family	781,203	55,195	23,860
Other Residential	148,667	25,859	12,179
Commercial	11,156	1,533	651
Industrial	1,678	218	80
Other	1,536	215	121
Total	944,240	83,020	36,891

Wood construction, the most prevalent building type in Missouri, sustains the most cases of complete damage. Approximately 15,000 wood frame buildings will experience complete damage, this equates to about 40% of all complete damage cases. Unreinforced masonry (URM) construction and mobile homes (MH) also show high frequencies of complete damage and account for about 58% of all complete damage cases. This damage state is identified by significant cracking to unreinforced masonry walls as well as some connection damage to column/beam joints in unreinforced masonry building. The

remaining building types show far less inventory throughout the state and thus experience a far lesser proportion of damage.

Table 242: Building Damage by Building Type for the State of Missouri

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,108,809	40,945	13,655	4,808	15,090
Steel	6,800	601	360	109	298
Concrete	2,166	156	70	27	84
Precast	2,291	179	129	41	97
Reinforced Masonry	1,493	121	77	20	69
Unreinforced Masonry	317,999	34,151	11,730	3,929	11,686
Mobile Home	149,399	20,868	8,177	4,544	9,567
Total	**1,588,957**	**97,021**	**34,198**	**13,478**	**36,891**

Table 243: Essential Facilities Damage & Functionality for the State of Missouri[9]

Essential Facilities Damage & Functionality (State)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	160	8	3	123
Schools	2,817	185	85	2,530
EOCs	33	7	4	25
Police Stations	654	61	32	587
Fire Stations	1,399	116	48	1,264

Table 244: Essential Facilities Damage & Functionality for the 46 Critical Counties

Essential Facilities Damage & Functionality (46 Critical Counties)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	79	8	3	42
Schools	1,435	185	85	1,148
EOCs	17	7	4	9
Police Stations	326	61	32	259
Fire Stations	647	116	48	512

Of the 1,399 fire stations in the state, 116 (more than 8%) are estimated to experience at least moderate damage. Approximately 8-10% of most other essential facility types

[9] For Tables 243-253 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

(schools, hospitals and police stations) each sustain at least moderate damage. Several emergency operation centers are expected to sustain this level of damage since they are located in the portion of the state which experiences the most severe shaking. All at least moderated damage of essential facilities is confined to the 46 critical counties.

All non-functional facilities are located in the southeastern portion of the state. Additionally, numerous hospitals in the St. Louis metropolitan area are not functional the first week after the earthquake. Of Missouri's 160 hospitals, 123 are considered functional the day after the earthquake and that number increases to 152 functional facilities after one week. Roughly 90% of all fire stations and police stations in Missouri are estimated to remain functional the day after the earthquake, though all these functioning facilities are in the northern and western portions of the state. Most of Missouri's southeastern counties are left without functioning facilities and will likely experience diminished services in the immediate aftermath of an earthquake.

Table 245: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
46 Critical Counties	7,803	1,363	659	6,447
Remaining Counties	13,962	0	0	13,962
Total State	21,765	1,363	659	20,409

Table 246: Airport Damage Assessments

Airport Damage Assessments				
	Total No. Of Airports	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
46 Critical Counties	208	33	5	182
Remaining Counties	350	0	0	350
Total State	558	33	5	532

As is the case with essential facilities, transportation lifelines located in southeastern Missouri Counties incur the most severe damage. Roughly 1,360 of the 21,800 bridges, or 6% of all bridges, are estimated to incur at least moderate damage. Of the 1,360 damaged bridges, 659 are expected to experience complete damage. Highway road segments connecting these damaged bridges are expected to incur slightly less damage than the bridges themselves, even in these counties with the most severe shaking. Highway segments are most generally defined as a section of highway between two end nodes. These end nodes are frequently highway bridges. At least moderate damage to highway bridges is characterized by moderate shear (diagonal) cracking of columns, spalling of cover concrete and shear keys, abutment movement less than two-inches, extensive cracking to shear keys, bent connection bolts and moderate settlement of the bridge approaches.

Furthermore, 27% of all ports and 16% of all airports reach the at least moderate damage state and follow roughly the same damage distribution throughout the state as highway bridges. At least moderate damage to port facilities includes considerable ground settlement, derailment of port equipment and damage to structural members. For airports, at least moderate damage is defined in the same manner as damage to other building types discussed previously. The lack of functionality of many transportation lifelines in southeastern Missouri will make the movement of people and supplies difficult in the days immediately following the earthquake.

Table 247: Transportation System Damage for the State of Missouri

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage >50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	4,186	0	0	4,185
	Bridges	21,765	1,363	659	20,409
	Tunnels	0	0	0	0
Railways	Segments	3,487	0	0	3,487
	Bridges	200	2	0	198
	Tunnels	12	0	0	12
	Facilities	125	24	0	109
Bus	Facilities	72	5	1	69
Light Rail	Segments	2	0	0	2
	Bridges	0	0	0	0
	Facilities	17	17	17	0
Ferry	Facilities	8	8	8	0
Port	Facilities	230	49	0	205
Airport	Facilities	558	33	5	532
	Runways	440	0	0	440

Table 248: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
46 Critical Counties	3,413	758	48	2,756
Remaining Counties	5,186	0	0	5,186
Total State	8,599	758	48	7,942

Utility lifelines show similar damage and functionality estimates to those of the transportation systems. Over 750 of all potable water facilities are moderately or more severely damaged while 48 incur complete damage. Additionally 88 waste water facilities, 1,573 communication facilities, and 96 electric power facilities incur at least moderate damage. Additionally, 65 natural gas facilities, or about 54% of all natural gas facilities located in the critical counties, experience at least moderate damage.

Table 249: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
46 Critical Counties	626	88	8	505
Remaining Counties	686	0	0	686
Total State	1,312	88	8	1,191

Table 250: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
46 Critical Counties	117	63	6	54
Remaining Counties	237	0	0	237
Total State	354	63	9	291

Table 251: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
46 Critical Counties	52	8	0	44
Remaining Counties	67	0	0	67
Total State	119	8	0	111

Table 252: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
46 Critical Counties	426	96	7	309
Remaining Counties	980	0	0	980
Total State	1,406	96	7	1,289

Table 253: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
46 Critical Counties	9,232	1,573	104	8,367
Remaining Counties	11,640	0	0	11,640
Total State	20,872	1,573	104	20,007

Pipeline damage is estimated for local potable water, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not included in the HAZUS-MH MR2 default inventory, called local inventory in HAZUS-MH MR2, though regional oil pipelines are added to provide damage estimates for these major oil transmission lines. These oil pipelines are composed of major crude oil and refined product lines only. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of both breaks and leaks at roughly 20,400 and 15,000, respectively. Local natural gas lines, however, show the greatest break and leak rates per length of pipe at roughly 0.19 leaks/mile (1 leak every 5.2 miles) or 0.26 breaks/mile (roughly 1 break every 3.8 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of approximately 12,950 leaks and 18,000 breaks over the combined length of 70,400 miles of natural gas pipeline.

Potable water service is cut off for over 146,000 residences the day after the scenario earthquake. This is reduced to roughly 80,000 residences within a week and nearly 38,000 customers are still without service after three months. Additionally, all service interruptions occur in the 46 critical counties. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program. This period of time without water prevents thousands of people from remaining in their homes in the weeks and months following the earthquake. Electric power service shows similar trends, with over 100,000 service outages the day after the earthquake, or nearly 5% of all state residences without power. Even a month after the earthquake nearly 13,000 residences are still without power. All electric power lines are presumed to be above ground and less likely to incur damage from moderate ground shaking unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation.

Table 254: Pipeline Damage

Pipeline Damage			
System	Total Pipelines (mi)	No. Leaks	No. Breaks
Potable Water – Local	165,831	15,052	20,409
Waste Water – Local	99,499	11,905	16,142
Natural Gas – Regional	4,087	223	754
Natural Gas – Local	66,312	12,726	17,255
Oil – Regional	6,413	60	163

Table 255: Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	2,194,594	146,368	115,391	79,848	77,818	38,426
Electric Power		100,141	70,720	39,499	12,955	121

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county. The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as discussed in footnote (9) and employed in the preceding damage tables for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Jefferson County, Missouri – 91 waste water facilities
    - Estimation procedure according to footnote 9:
        - Summation of individual facilities after that facility is deemed ‘damaged’ or ‘undamaged’ based on 50% or greater damage likelihood requirement estimates **0 at least moderately damaged waste water facilities**
    - Estimation procedure according to topic damage tables in this appendix:
        - To determine the percentage of waste water facilities in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of facilities in that county
        - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **11 at least moderately damaged waste water facilities**

In the case of Jefferson County, Missouri, the topic damage tables in this appendix provide a higher estimate of damage as opposed to the facility-by-facility damage summation detailed in footnote (9). Though not illustrated here, other counties in Missouri are estimated to incur less damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged waste water facilities for the 46 critical counties in Missouri shows the following:

- Total number of at least moderately damaged waste water facilities according to the HAZUS-MH MR2 procedure for averaging damage at the county level
    - **108 at least moderately damaged waste water facilities**
- Total number of at least moderately damaged waste water facilities according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
    - **88 at least moderately damaged waste water facilities**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces more damage. Other infrastructure categories may or may not follow this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix.

The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Missouri. There tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage levels for a county.

Table 256: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Audrain						
Single Family	7,077	77	6	0	0	7,160
Other Residential	1,056	90	11	0	0	1,157
Commercial	65	2	0	0	0	67
Industrial	17	0	0	0	0	17
Other	18	1	0	0	0	19
Bollinger						
Single Family	1,385	972	427	165	227	3,176
Other Residential	191	200	287	291	239	1,208
Commercial	6	4	4	2	1	17
Industrial	0	0	0	0	0	0
Other	2	1	2	1	0	6
Boone						
Single Family	28,969	317	26	0	0	29,312
Other Residential	8,202	504	61	0	0	8,767
Commercial	582	15	2	0	0	599
Industrial	46	1	0	0	0	47
Other	75	2	0	0	0	77
Butler						
Single Family	952	3,811	2,412	492	2,951	10,618
Other Residential	35	135	147	507	2,101	2,925
Commercial	0	0	7	38	159	204
Industrial	0	0	0	3	20	23
Other	0	2	2	4	26	34
Callaway						
Single Family	9,316	102	8	0	0	9,426
Other Residential	3,465	332	41	0	0	3,838
Commercial	57	1	0	0	0	58
Industrial	4	0	0	0	0	4
Other	9	0	0	0	0	9
Cape Girardeau						
Single Family	8,056	5,565	2,142	906	887	17,556
Other Residential	771	812	942	729	271	3,525
Commercial	24	50	118	84	35	311
Industrial	2	3	9	9	4	27
Other	7	5	8	6	2	28
Carter						
Single Family	974	387	133	50	37	1,581
Other Residential	102	129	252	224	56	763
Commercial	8	4	3	2	1	18
Industrial	2	1	1	0	0	4
Other	3	1	1	0	0	5

Cole						
Single Family	17,752	194	16	0	0	17,962
Other Residential	2,630	140	17	0	0	2,787
Commercial	264	7	1	0	0	272
Industrial	22	1	0	0	0	23
Other	186	5	1	0	0	192
Crawford						
Single Family	6,392	70	6	0	0	6,468
Other Residential	1,757	180	22	0	0	1,959
Commercial	53	1	0	0	0	54
Industrial	2	0	0	0	0	2
Other	6	0	0	0	0	6
Dent						
Single Family	3,785	41	3	0	0	3,829
Other Residential	1,337	131	16	0	0	1,484
Commercial	45	1	0	0	0	46
Industrial	8	0	0	0	0	8
Other	12	0	0	0	0	12
Douglas						
Single Family	3,344	37	3	0	0	3,384
Other Residential	1,070	109	13	0	0	1,192
Commercial	24	1	0	0	0	25
Industrial	0	0	0	0	0	0
Other	2	0	0	0	0	2
Dunklin						
Single Family	124	782	1,630	1,292	4,677	8,505
Other Residential	2	13	58	123	1,737	1,933
Commercial	0	0	0	1	73	74
Industrial	0	0	0	0	9	9
Other	0	0	0	0	7	7
Franklin						
Single Family	24,800	271	22	0	0	25,093
Other Residential	5,489	521	64	0	0	6,074
Commercial	231	6	1	0	0	238
Industrial	63	2	0	0	0	65
Other	28	1	0	0	0	29
Gasconade						
Single Family	4,596	50	4	0	0	4,650
Other Residential	1,229	121	15	0	0	1,365
Commercial	32	1	0	0	0	33
Industrial	12	0	0	0	0	12
Other	7	0	0	0	0	7
Howell						
Single Family	8,520	93	8	0	0	8,621
Other Residential	3,058	304	38	0	0	3,400
Commercial	112	3	0	0	0	115
Industrial	11	0	0	0	0	11
Other	11	0	0	0	0	11

Iron						
Single Family	2,290	393	73	4	0	2,760
Other Residential	437	369	211	5	0	1,022
Commercial	13	6	2	0	0	21
Industrial	3	1	1	0	0	5
Other	5	2	1	0	0	8
Jefferson						
Single Family	44,179	4,922	899	46	124	50,170
Other Residential	9,447	2,807	1,274	29	62	13,619
Commercial	297	83	33	2	1	416
Industrial	45	8	4	0	0	57
Other	36	8	3	0	0	47
Lincoln						
Single Family	9,452	103	8	0	0	9,563
Other Residential	3,483	356	44	0	0	3,883
Commercial	55	1	0	0	0	56
Industrial	5	0	0	0	0	5
Other	3	0	0	0	0	3
Madison						
Single Family	2,564	498	92	5	37	3,196
Other Residential	444	358	204	5	12	1,023
Commercial	19	8	3	0	0	30
Industrial	6	3	1	0	0	10
Other	5	2	1	0	0	8
Maries						
Single Family	2,321	25	2	0	0	2,348
Other Residential	844	85	11	0	0	940
Commercial	15	0	0	0	0	15
Industrial	2	0	0	0	0	2
Other	6	0	0	0	0	6
Miller						
Single Family	6,238	68	5	0	0	6,311
Other Residential	1,877	185	23	0	0	2,085
Commercial	54	1	0	0	0	55
Industrial	9	0	0	0	0	9
Other	8	0	0	0	0	8
Mississippi						
Single Family	310	1,191	874	224	925	3,524
Other Residential	18	86	187	171	192	654
Commercial	0	2	7	5	7	21
Industrial	0	0	1	1	1	3
Other	0	1	2	2	2	7
Montgomery						
Single Family	3,684	40	3	0	0	3,727
Other Residential	851	86	11	0	0	948
Commercial	31	1	0	0	0	32
Industrial	7	0	0	0	0	7
Other	9	0	0	0	0	9

New Madrid						
Single Family	26	424	1,226	854	2,154	4,684
Other Residential	2	31	161	295	1,040	1,529
Commercial	0	0	4	10	33	47
Industrial	0	0	0	1	4	5
Other	0	0	0	1	7	8
Oregon						
Single Family	2,311	255	46	4	13	2,629
Other Residential	607	284	150	4	6	1,051
Commercial	22	3	1	0	0	26
Industrial	3	0	0	0	0	3
Other	7	1	0	0	0	8
Osage						
Single Family	3,962	43	3	0	0	4,008
Other Residential	637	63	8	0	0	708
Commercial	20	1	0	0	0	21
Industrial	30	1	0	0	0	31
Other	12	0	0	0	0	12
Ozark						
Single Family	2,803	31	2	0	0	2,836
Other Residential	1,147	121	15	0	0	1,283
Commercial	18	0	0	0	0	18
Industrial	2	0	0	0	0	2
Other	5	0	0	0	0	5
Pemiscot						
Single Family	21	352	1,259	938	2,214	4,784
Other Residential	0	9	59	128	1,007	1,203
Commercial	0	0	1	4	37	42
Industrial	0	0	0	0	3	3
Other	0	0	1	3	39	43
Perry						
Single Family	4,122	784	145	12	33	5,096
Other Residential	479	376	213	6	6	1,080
Commercial	46	20	8	1	1	76
Industrial	10	5	2	0	0	17
Other	13	5	2	0	0	20
Phelps						
Single Family	9,106	100	8	0	0	9,214
Other Residential	2,887	254	31	0	0	3,172
Commercial	109	3	0	0	0	112
Industrial	5	0	0	0	0	5
Other	23	1	0	0	0	24
Pike						
Single Family	4,424	48	4	0	0	4,476
Other Residential	1,076	107	13	0	0	1,196
Commercial	64	2	0	0	0	66
Industrial	2	0	0	0	0	2
Other	14	0	0	0	0	14

Pulaski						
Single Family	7,902	86	7	0	0	7,995
Other Residential	3,063	267	33	0	0	3,363
Commercial	111	3	0	0	0	114
Industrial	6	0	0	0	0	6
Other	34	1	0	0	0	35
Reynolds						
Single Family	1,823	313	59	5	20	2,220
Other Residential	294	257	148	4	6	709
Commercial	7	3	1	0	0	11
Industrial	3	2	1	0	0	6
Other	3	1	0	0	0	4
Ripley						
Single Family	483	1,200	956	317	309	3,265
Other Residential	9	78	421	636	497	1,641
Commercial	1	3	11	9	6	30
Industrial	0	1	3	5	4	13
Other	0	1	1	1	1	4
Saint Charles						
Single Family	76,484	836	67	1	0	77,388
Other Residential	6,599	524	64	0	0	7,187
Commercial	762	19	2	0	0	783
Industrial	94	3	0	0	0	97
Other	97	3	0	0	0	100
Saint Francois						
Single Family	11,667	1,388	255	13	0	13,323
Other Residential	2,305	1,010	516	12	0	3,843
Commercial	100	36	14	1	0	151
Industrial	9	3	2	0	0	14
Other	9	3	1	0	0	13
Saint Louis City						
Single Family	47,742	8,032	1,498	78	2,350	59,700
Other Residential	19,113	3,372	696	35	1,821	25,037
Commercial	910	386	159	12	157	1,624
Industrial	138	63	34	3	21	259
Other	310	63	23	1	13	410
Saint Louis						
Single Family	269,941	20,609	3,660	184	344	294,738
Other Residential	10,908	1,163	273	12	37	12,393
Commercial	3,963	626	235	16	4	4,844
Industrial	663	85	40	3	2	793
Other	147	41	15	1	9	213
Sainte Genevieve						
Single Family	4,183	717	134	7	0	5,041
Other Residential	565	481	276	7	0	1,329
Commercial	29	12	5	0	0	46
Industrial	10	5	3	0	0	18
Other	3	1	0	0	0	4

Scott						
Single Family	1,593	3,205	2,111	805	2,483	10,197
Other Residential	49	192	557	757	1,010	2,565
Commercial	1	5	22	32	56	116
Industrial	0	1	3	5	7	16
Other	0	2	3	5	10	20
Shannon						
Single Family	1,667	286	53	3	0	2,009
Other Residential	298	261	151	4	0	714
Commercial	6	3	1	0	0	10
Industrial	1	1	0	0	0	2
Other	2	1	0	0	0	3
Stoddard						
Single Family	95	615	1,910	1,632	3,790	8,042
Other Residential	1	6	69	207	1,490	1,773
Commercial	0	0	1	5	79	85
Industrial	0	0	0	0	5	5
Other	0	0	0	0	2	2
Texas						
Single Family	5,488	60	5	0	0	5,553
Other Residential	2,123	214	26	0	0	2,363
Commercial	57	1	0	0	0	58
Industrial	14	0	0	0	0	14
Other	17	0	0	0	0	17
Warren						
Single Family	7,136	78	6	0	0	7,220
Other Residential	1,902	193	24	0	0	2,119
Commercial	44	1	0	0	0	45
Industrial	7	0	0	0	0	7
Other	12	0	0	0	0	12
Washington						
Single Family	3,834	383	69	4	0	4,290
Other Residential	2,364	750	350	8	0	3,472
Commercial	18	6	2	0	0	26
Industrial	3	1	1	0	0	5
Other	13	3	1	0	0	17
Wayne						
Single Family	1,014	1,247	782	228	284	3,555
Other Residential	239	280	576	704	587	2,386
Commercial	11	6	5	3	3	28
Industrial	2	1	1	1	0	5
Other	2	2	1	1	2	8

Table 257: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Audrain	201	194	96.5	194	96.5	200	99.5	201	100.0	201	100.0
Bollinger	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Boone	1,227	1,183	96.4	1,184	96.5	1,218	99.3	1,226	99.9	1,226	99.9
Butler	483	23	4.8	26	5.4	116	24.0	372	77.0	403	83.4
Callaway	557	537	96.4	538	96.6	553	99.3	556	99.8	556	99.8
Cape Girardeau	545	185	33.9	190	34.9	379	69.5	528	96.9	531	97.4
Carter	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cole	302	291	96.4	291	96.4	300	99.3	302	100.0	302	100.0
Crawford	75	72	96.0	72	96.0	74	98.7	75	100.0	75	100.0
Dent	59	57	96.6	57	96.6	59	100.0	59	100.0	59	100.0
Douglas	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dunklin	118	0	0.0	0	0.0	0	0.0	1	0.8	14	11.9
Franklin	187	180	96.3	180	96.3	186	99.5	187	100.0	187	100.0
Gasconade	44	42	95.5	42	95.5	44	100.0	44	100.0	44	100.0
Howell	162	156	96.3	156	96.3	161	99.4	162	100.0	162	100.0
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jefferson	236	113	47.9	114	48.3	174	73.7	230	97.5	233	98.7
Lincoln	72	69	95.8	69	95.8	71	98.6	72	100.0	72	100.0
Madison	159	131	82.4	131	82.4	153	96.2	159	100.0	159	100.0
Maries	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Miller	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mississippi	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Montgomery	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
New Madrid	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Oregon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Osage	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ozark	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pemiscot	209	0	0.0	0	0.0	0	0.0	6	2.9	42	20.1
Perry	64	30	46.9	31	48.4	47	73.4	62	96.9	63	98.4
Phelps	240	231	96.3	232	96.7	238	99.2	240	100.0	240	100.0
Pike	45	43	95.6	43	95.6	45	100.0	45	100.0	45	100.0
Pulaski	75	72	96.0	72	96.0	74	98.7	75	100.0	75	100.0
Reynolds	159	75	47.2	76	47.8	116	73.0	154	96.9	156	98.1
Ripley	30	3	10.0	3	10.0	11	36.7	26	86.7	27	90.0
Saint Charles	743	716	96.4	717	96.5	738	99.3	742	99.9	742	99.9
Sainte Genevieve	47	22	46.8	23	48.9	35	74.5	46	97.9	46	97.9
Saint Francois	464	297	64.0	299	64.4	381	82.1	456	98.3	460	99.1
Saint Louis County & Saint Louis City	8,176	5,062	61.9	5,095	62.3	6,479	79.2	7,734	94.6	7,795	95.3
Scott	188	8	4.3	8	4.3	38	20.2	121	64.4	130	69.1
Shannon	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Stoddard	50	0	0.0	0	0.0	0	0.0	2	4.0	13	26.0
Texas	66	64	97.0	64	97.0	66	100.0	66	100.0	66	100.0
Warren	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Washington	40	19	47.5	19	47.5	29	72.5	39	97.5	40	100.0
Wayne	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 258: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Audrain	4	94.10
Bollinger	2	7.00
Boone	8	94.10
Butler	3	0.00
Callaway	5	94.10
Cape Girardeau	5	29.08
Carter	2	51.40
Cole	8	94.10
Crawford	5	94.10
Dent	2	94.10
Douglas	2	94.10
Dunklin	10	0.00
Franklin	7	94.10
Gasconade	4	94.10
Howell	5	94.10
Iron	3	51.90
Jefferson	14	57.93
Lincoln	7	94.10
Madison	2	69.80
Maries	3	94.10
Miller	4	94.10
Mississippi	4	2.28
Montgomery	7	94.10
New Madrid	11	0.00
Oregon	3	65.63
Osage	2	94.10
Ozark	2	94.10
Pemiscot	8	0.00
Perry	2	51.40
Phelps	6	94.10
Pike	4	94.10
Pulaski	7	94.10
Reynolds	2	51.40
Ripley	2	2.90
Saint Charles	9	94.10
Saint Francois	11	63.41
Sainte Genevieve	3	49.63
Saint Louis City	7	48.01
Saint Louis	95	67.82
Scott	8	2.28
Shannon	4	51.90
Stoddard	8	0.00
Texas	5	94.10
Warren	5	94.10
Washington	3	51.90
Wayne	3	23.70

Table 259: School Functionality

Counties	Count	Functionality at Day 1 (%)
Audrain	15	94.10
Bollinger	8	19.25
Boone	57	94.10
Butler	20	0.00
Callaway	23	94.10
Cape Girardeau	37	24.13
Carter	6	26.15
Cole	34	94.10
Crawford	13	94.10
Dent	9	94.10
Douglas	3	94.10
Dunklin	21	0.00
Franklin	58	94.10
Gasconade	11	94.10
Howell	19	94.10
Iron	9	51.90
Jefferson	71	64.38
Lincoln	20	94.10
Madison	5	68.90
Maries	5	94.10
Miller	14	94.10
Mississippi	10	2.26
Montgomery	8	94.10
New Madrid	15	0.00
Oregon	8	60.33
Osage	11	94.10
Ozark	4	94.10
Pemiscot	19	0.00
Perry	10	51.45
Phelps	21	94.10
Pike	13	94.10
Pulaski	23	94.10
Reynolds	8	51.53
Ripley	10	2.76
Saint Charles	98	94.10
Saint Francois	27	58.12
Sainte Genevieve	9	51.14
Saint Louis City	159	47.97
Saint Louis	421	72.95
Scott	31	2.19
Shannon	4	51.90
Stoddard	20	0.00
Texas	14	94.10
Warren	11	94.10
Washington	14	69.99
Wayne	7	38.54

Table 260: Fire Station Functionality

Counties	Count	Functionality at Day 1 (%)
Audrain	7	94.10
Bollinger	10	27.30
Boone	27	94.10
Butler	19	0.00
Callaway	19	94.10
Cape Girardeau	18	30.06
Carter	7	22.51
Cole	19	94.10
Crawford	10	94.10
Dent	5	94.10
Douglas	9	94.10
Dunklin	12	0.00
Franklin	26	94.10
Gasconade	11	94.10
Howell	18	94.10
Iron	7	51.90
Jefferson	32	69.04
Lincoln	10	94.10
Madison	3	68.30
Maries	5	94.10
Miller	19	94.10
Mississippi	5	2.28
Montgomery	8	94.10
New Madrid	10	0.00
Oregon	8	65.61
Osage	7	94.10
Ozark	14	94.10
Pemiscot	5	0.00
Perry	6	50.60
Phelps	9	94.10
Pike	8	94.10
Pulaski	12	94.10
Reynolds	7	51.47
Ripley	12	3.73
Saint Charles	33	94.10
Saint Francois	16	67.73
Sainte Genevieve	9	51.14
Saint Louis	85	75.01
Saint Louis City	27	48.63
Scott	14	1.26
Shannon	5	51.90
Stoddard	9	0.00
Texas	12	94.10
Warren	10	94.10
Washington	11	74.92
Wayne	12	17.57

Table 261: Communication Facility Functionality

Counties	# of Facilities	At Day 1 (%)	At Day 3 (%)	At Day 7 (%)	At Day 30 (%)	At Day 90 (%)
Audrain	208	99.80	99.90	99.90	99.90	99.90
Bollinger	81	62.33	83.83	88.57	97.87	99.59
Boone	499	99.80	99.90	99.90	99.90	99.90
Butler	189	42.34	62.62	70.66	89.57	98.11
Callaway	231	99.75	99.90	99.90	99.90	99.90
Cape Girardeau	325	66.04	86.11	90.03	97.66	99.55
Carter	40	76.75	93.04	95.40	99.38	99.88
Cole	284	99.78	99.90	99.90	99.90	99.90
Crawford	121	93.20	98.90	99.40	99.90	99.90
Dent	63	93.20	98.90	99.40	99.90	99.90
Douglas	48	99.80	99.90	99.90	99.90	99.90
Dunklin	160	25.87	37.51	46.56	72.65	95.12
Franklin	300	96.44	99.41	99.66	99.90	99.90
Gasconade	94	99.50	99.90	99.90	99.90	99.90
Howell	171	93.20	98.90	99.40	99.90	99.90
Iron	77	82.82	95.46	97.09	99.62	99.90
Jefferson	541	93.18	98.88	99.38	99.89	99.90
Lincoln	150	99.80	99.90	99.90	99.90	99.90
Madison	61	71.94	90.24	93.41	99.04	99.80
Maries	55	99.50	99.90	99.90	99.90	99.90
Miller	128	99.80	99.90	99.90	99.90	99.90
Mississippi	64	56.33	74.37	78.54	88.78	97.96
Montgomery	131	99.80	99.90	99.90	99.90	99.90
New Madrid	161	29.09	42.43	51.05	75.38	95.60
Oregon	55	84.32	95.96	97.42	99.66	99.90
Osage	100	99.50	99.90	99.90	99.90	99.90
Ozark	44	99.80	99.90	99.90	99.90	99.90
Pemiscot	125	25.40	37.18	46.48	73.08	95.22
Perry	111	77.74	93.19	95.29	98.87	99.78
Phelps	172	93.82	99.00	99.45	99.90	99.90
Pike	137	99.80	99.90	99.90	99.90	99.90
Pulaski	136	99.69	99.90	99.90	99.90	99.90
Reynolds	63	78.40	94.00	96.10	99.50	99.90
Ripley	64	54.48	76.79	82.98	95.91	99.23
Saint Charles	566	99.59	99.90	99.90	99.90	99.90
Saint Francois	198	87.59	97.04	98.15	99.75	99.90
Sainte Genevieve	107	91.89	98.43	99.06	99.81	99.89
Saint Louis	1,614	95.34	99.22	99.55	99.88	99.90
Saint Louis City	755	92.74	98.40	98.89	99.47	99.81
Scott	187	54.64	74.31	79.38	91.07	98.38
Shannon	48	93.20	98.90	99.40	99.90	99.90
Stoddard	162	32.74	48.84	58.23	82.37	96.83
Texas	134	93.20	98.90	99.40	99.90	99.90
Warren	125	99.59	99.90	99.90	99.90	99.90
Washington	82	93.20	98.90	99.40	99.90	99.90
Wayne	65	53.15	74.95	81.58	95.64	99.16

Table 262: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Audrain	9,844	0.00	0.00	0.00	0.00	0.00
Bollinger	4,576	22.68	4.63	0.00	0.00	0.00
Boone	53,094	0.00	0.00	0.00	0.00	0.00
Butler	16,718	98.79	98.68	98.44	95.36	0.00
Callaway	14,416	0.00	0.00	0.00	0.00	0.00
Cape Girardeau	26,980	40.30	28.74	4.63	0.00	0.00
Carter	2,378	0.00	0.00	0.00	0.00	0.00
Cole	27,040	0.00	0.00	0.00	0.00	0.00
Crawford	8,858	0.00	0.00	0.00	0.00	0.00
Dent	5,982	0.00	0.00	0.00	0.00	0.00
Douglas	5,201	0.00	0.00	0.00	0.00	0.00
Dunklin	13,411	99.87	99.86	99.84	99.66	94.97
Franklin	34,945	0.00	0.00	0.00	0.00	0.00
Gasconade	6,171	0.00	0.00	0.00	0.00	0.00
Howell	14,762	0.00	0.00	0.00	0.00	0.00
Iron	4,197	0.00	0.00	0.00	0.00	0.00
Jefferson	71,499	0.00	0.00	0.00	0.00	0.00
Lincoln	13,851	0.00	0.00	0.00	0.00	0.00
Madison	4,711	0.02	0.00	0.00	0.00	0.00
Maries	3,519	0.00	0.00	0.00	0.00	0.00
Miller	9,284	0.00	0.00	0.00	0.00	0.00
Mississippi	5,383	99.83	99.81	99.76	98.77	0.00
Montgomery	4,775	0.00	0.00	0.00	0.00	0.00
New Madrid	7,824	99.90	99.88	99.87	99.72	94.85
Oregon	4,263	0.00	0.00	0.00	0.00	0.00
Osage	4,922	0.00	0.00	0.00	0.00	0.00
Ozark	3,950	0.00	0.00	0.00	0.00	0.00
Pemiscot	7,855	99.86	99.85	99.82	99.50	58.93
Perry	6,904	0.00	0.00	0.00	0.00	0.00
Phelps	15,683	0.00	0.00	0.00	0.00	0.00
Pike	6,451	0.00	0.00	0.00	0.00	0.00
Pulaski	13,433	0.00	0.00	0.00	0.00	0.00
Reynolds	2,721	0.00	0.00	0.00	0.00	0.00
Ripley	5,416	15.27	1.02	0.00	0.00	0.00
Saint Charles	101,663	0.00	0.00	0.00	0.00	0.00
Saint Francois	6,586	0.00	0.00	0.00	0.00	0.00
Sainte Genevieve	20,793	0.00	0.00	0.00	0.00	0.00
Saint Louis	404,312	0.00	0.00	0.00	0.00	0.00
Saint Louis City	147,076	35.84	18.51	0.00	0.00	0.00
Scott	15,626	99.85	99.83	99.81	99.43	11.15
Shannon	3,319	0.00	0.00	0.00	0.00	0.00
Stoddard	12,064	99.88	99.88	99.87	99.78	98.61
Texas	9,378	0.00	0.00	0.00	0.00	0.00
Warren	9,185	0.00	0.00	0.00	0.00	0.00
Washington	8,406	0.00	0.00	0.00	0.00	0.00
Wayne	5,551	41.97	28.30	1.50	0.00	0.00

Table 263: Potable Water Facility Damage

Counties	# Facilities	None	Slight	Moderate	Extensive	Complete
Audrain	40	0.97	0.03	0.00	0.00	0.00
Bollinger	23	0.08	0.31	0.41	0.17	0.04
Boone	137	0.97	0.03	0.00	0.00	0.00
Butler	86	0.02	0.13	0.36	0.31	0.18
Callaway	91	0.95	0.05	0.00	0.00	0.00
Cape Girardeau	119	0.10	0.34	0.38	0.13	0.05
Carter	28	0.15	0.39	0.35	0.10	0.01
Cole	92	0.96	0.04	0.00	0.00	0.00
Crawford	87	0.50	0.38	0.11	0.01	0.00
Dent	36	0.50	0.38	0.11	0.01	0.00
Douglas	33	0.97	0.03	0.00	0.00	0.00
Dunklin	63	0.00	0.03	0.17	0.34	0.46
Franklin	212	0.65	0.27	0.07	0.01	0.00
Gasconade	42	0.90	0.09	0.01	0.00	0.00
Howell	81	0.50	0.38	0.11	0.01	0.00
Iron	51	0.30	0.41	0.24	0.05	0.00
Jefferson	277	0.50	0.38	0.11	0.01	0.00
Lincoln	126	0.97	0.03	0.00	0.00	0.00
Madison	33	0.16	0.39	0.35	0.10	0.01
Maries	27	0.90	0.09	0.01	0.00	0.00
Miller	116	0.97	0.03	0.00	0.00	0.00
Mississippi	43	0.06	0.25	0.35	0.15	0.19
Montgomery	49	0.97	0.03	0.00	0.00	0.00
New Madrid	78	0.01	0.06	0.22	0.31	0.40
Oregon	28	0.35	0.40	0.21	0.04	0.00
Osage	41	0.90	0.09	0.01	0.00	0.00
Ozark	66	0.97	0.03	0.00	0.00	0.00
Pemiscot	68	0.00	0.03	0.17	0.36	0.45
Perry	40	0.20	0.42	0.31	0.07	0.01
Phelps	94	0.53	0.35	0.10	0.01	0.00
Pike	45	0.97	0.03	0.00	0.00	0.00
Pulaski	88	0.95	0.05	0.00	0.00	0.00
Reynolds	50	0.20	0.42	0.31	0.07	0.01
Ripley	32	0.08	0.27	0.39	0.19	0.08
Saint Charles	140	0.94	0.05	0.00	0.00	0.00
Saint Francois	117	0.38	0.39	0.19	0.03	0.00
Sainte Genevieve	54	0.43	0.38	0.16	0.02	0.01
Saint Louis	87	0.67	0.25	0.07	0.01	0.00
Saint Louis City	2	0.90	0.09	0.01	0.00	0.00
Scott	84	0.05	0.23	0.36	0.18	0.18
Shannon	33	0.50	0.38	0.11	0.01	0.00
Stoddard	90	0.00	0.05	0.22	0.37	0.36
Texas	62	0.50	0.38	0.11	0.01	0.00
Warren	72	0.92	0.07	0.01	0.00	0.00
Washington	73	0.50	0.38	0.11	0.01	0.00
Wayne	77	0.04	0.23	0.42	0.25	0.07

Table 264: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Audrain	1,468	8	2
Bollinger	1,072	103	116
Boone	2,080	11	3
Butler	1,717	847	1,905
Callaway	1,866	10	3
Cape Girardeau	1,628	379	238
Carter	812	11	26
Cole	1,217	7	2
Crawford	1,732	9	2
Dent	1,412	8	2
Douglas	1,574	9	2
Dunklin	1,543	1,383	3,254
Franklin	2,927	16	4
Gasconade	1,107	6	2
Howell	2,116	12	3
Iron	832	5	1
Jefferson	2,821	17	12
Lincoln	1,586	9	2
Madison	789	12	30
Maries	967	5	1
Miller	1,471	8	2
Mississippi	821	929	1,647
Montgomery	1,187	6	2
New Madrid	1,394	2,078	3,149
Oregon	1,308	10	12
Osage	1,090	6	1
Ozark	1,465	8	2
Pemiscot	1,195	923	2,483
Perry	1,111	20	12
Phelps	1,661	9	2
Pike	1,231	7	2
Pulaski	1,426	8	2
Reynolds	1,239	10	14
Ripley	1,112	75	100
Saint Charles	2,372	13	3
Saint Francois	1,468	8	2
Sainte Genevieve	1,022	6	1
Saint Louis	4,989	30	19
Saint Louis City	1,160	46	162
Scott	1,123	2,908	2,314
Shannon	1,637	9	2
Stoddard	1,922	3,417	4,260
Texas	2,389	13	3
Warren	1,116	6	2
Washington	1,632	9	2
Wayne	1,362	72	210

Table 265: Households without Electric Service

Counties	# of Households	At Day 1 (%)	At Day 3 (%)	At Day 7 (%)	At Day 30 (%)	At Day 90 (%)
Audrain	9,844	0.00	0.00	0.00	0.00	0.00
Bollinger	4,576	72.95	39.27	12.08	1.75	0.11
Boone	53,094	0.00	0.00	0.00	0.00	0.00
Butler	16,718	86.54	62.17	31.94	8.63	0.10
Callaway	14,416	0.00	0.00	0.00	0.00	0.00
Cape Girardeau	26,980	65.41	33.59	9.76	1.50	0.09
Carter	2,378	40.79	20.77	5.80	0.76	0.04
Cole	27,040	0.00	0.00	0.00	0.00	0.00
Crawford	8,858	0.00	0.00	0.00	0.00	0.00
Dent	5,982	0.00	0.00	0.00	0.00	0.00
Douglas	5,201	0.00	0.00	0.00	0.00	0.00
Dunklin	13,411	94.16	82.72	60.70	23.32	0.10
Franklin	34,945	0.00	0.00	0.00	0.00	0.00
Gasconade	6,171	0.00	0.00	0.00	0.00	0.00
Howell	14,762	0.00	0.00	0.00	0.00	0.00
Iron	4,197	0.00	0.00	0.00	0.00	0.00
Jefferson	71,499	0.00	0.00	0.00	0.00	0.00
Lincoln	13,851	0.00	0.00	0.00	0.00	0.00
Madison	4,711	21.21	10.80	3.01	0.38	0.02
Maries	3,519	0.00	0.00	0.00	0.00	0.00
Miller	9,284	0.00	0.00	0.00	0.00	0.00
Mississippi	5,383	77.30	49.21	25.82	9.77	0.09
Montgomery	4,775	0.00	0.00	0.00	0.00	0.00
New Madrid	7,824	91.95	76.69	52.72	19.75	0.10
Oregon	4,263	0.00	0.00	0.00	0.00	0.00
Osage	4,922	0.00	0.00	0.00	0.00	0.00
Ozark	3,950	0.00	0.00	0.00	0.00	0.00
Pemiscot	7,855	94.25	82.39	59.20	22.00	0.10
Perry	6,904	0.00	0.00	0.00	0.00	0.00
Phelps	15,683	0.00	0.00	0.00	0.00	0.00
Pike	6,451	0.00	0.00	0.00	0.00	0.00
Pulaski	13,433	0.00	0.00	0.00	0.00	0.00
Reynolds	2,721	0.00	0.00	0.00	0.00	0.00
Ripley	5,416	62.85	38.52	14.27	2.44	0.07
Saint Charles	101,663	0.00	0.00	0.00	0.00	0.00
Saint Francois	6,586	0.00	0.00	0.00	0.00	0.00
Sainte Genevieve	20,793	0.00	0.00	0.00	0.00	0.00
Saint Louis	404,312	0.00	0.00	0.00	0.00	0.00
Saint Louis City	147,076	0.00	0.00	0.00	0.00	0.00
Scott	15,626	78.90	50.65	25.07	8.40	0.10
Shannon	3,319	0.00	0.00	0.00	0.00	0.00
Stoddard	12,064	92.66	78.71	54.79	20.04	0.10
Texas	9,378	0.00	0.00	0.00	0.00	0.00
Warren	9,185	0.00	0.00	0.00	0.00	0.00
Washington	8,406	0.00	0.00	0.00	0.00	0.00
Wayne	5,551	79.64	49.58	19.62	3.68	0.11

Table 266: Waste Water Facility Damage

Counties	# of Facilities	None	Slight	Moderate	Extensive	Complete
Audrain	12	0.97	0.03	0.00	0.00	0.00
Bollinger	1	0.09	0.33	0.41	0.15	0.02
Boone	71	0.97	0.03	0.00	0.00	0.00
Butler	9	0.02	0.15	0.36	0.29	0.18
Callaway	37	0.94	0.06	0.00	0.00	0.00
Cape Girardeau	19	0.11	0.35	0.38	0.12	0.04
Carter	3	0.12	0.36	0.38	0.12	0.02
Cole	23	0.95	0.04	0.00	0.00	0.00
Crawford	8	0.50	0.38	0.11	0.01	0.00
Dent	5	0.50	0.38	0.11	0.01	0.00
Douglas	1	0.97	0.03	0.00	0.00	0.00
Dunklin	9	0.00	0.05	0.21	0.33	0.42
Franklin	55	0.69	0.24	0.06	0.01	0.00
Gasconade	9	0.90	0.09	0.01	0.00	0.00
Howell	4	0.50	0.38	0.11	0.01	0.00
Iron	6	0.25	0.41	0.28	0.06	0.01
Jefferson	91	0.50	0.38	0.11	0.01	0.00
Lincoln	19	0.97	0.03	0.00	0.00	0.00
Madison	5	0.15	0.39	0.35	0.10	0.01
Maries	2	0.90	0.09	0.01	0.00	0.00
Miller	16	0.97	0.03	0.00	0.00	0.00
Mississippi	6	0.07	0.28	0.34	0.12	0.18
Montgomery	10	0.97	0.03	0.00	0.00	0.00
New Madrid	11	0.00	0.05	0.19	0.31	0.45
Oregon	2	0.35	0.40	0.21	0.04	0.00
Osage	4	0.90	0.09	0.01	0.00	0.00
Ozark	1	0.97	0.03	0.00	0.00	0.00
Pemiscot	5	0.00	0.02	0.14	0.35	0.49
Perry	5	0.19	0.42	0.30	0.06	0.02
Phelps	19	0.56	0.33	0.10	0.01	0.00
Pike	7	0.97	0.03	0.00	0.00	0.00
Pulaski	13	0.93	0.06	0.00	0.00	0.00
Reynolds	6	0.20	0.42	0.31	0.07	0.01
Ripley	4	0.07	0.26	0.38	0.19	0.09
Saint Charles	19	0.95	0.05	0.00	0.00	0.00
Saint Francois	13	0.41	0.39	0.17	0.03	0.00
Sainte Genevieve	6	0.40	0.39	0.18	0.03	0.00
Saint Louis	6	0.40	0.39	0.18	0.03	0.00
Saint Louis City	2	0.50	0.37	0.11	0.01	0.01
Scott	9	0.07	0.27	0.37	0.16	0.14
Shannon	4	0.50	0.38	0.11	0.01	0.00
Stoddard	11	0.01	0.07	0.24	0.34	0.34
Texas	6	0.50	0.38	0.11	0.01	0.00
Warren	18	0.94	0.06	0.00	0.00	0.00
Washington	7	0.50	0.38	0.11	0.01	0.00
Wayne	6	0.04	0.22	0.41	0.26	0.07

Table 267: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Audrain	881	6	2
Bollinger	643	82	92
Boone	1,248	9	2
Butler	1,030	670	1,507
Callaway	1,119	8	2
Cape Girardeau	977	299	188
Carter	487	8	20
Cole	730	5	1
Crawford	1,039	7	2
Dent	847	6	2
Douglas	945	7	2
Dunklin	926	1,093	2,574
Franklin	1,756	13	3
Gasconade	664	5	1
Howell	1,270	9	2
Iron	499	4	1
Jefferson	1,692	14	9
Lincoln	951	7	2
Madison	473	9	24
Maries	580	4	1
Miller	882	6	2
Mississippi	492	735	1,303
Montgomery	712	5	1
New Madrid	837	1,643	2,490
Oregon	785	8	10
Osage	654	5	1
Ozark	879	6	2
Pemiscot	717	730	1,964
Perry	667	16	10
Phelps	996	7	2
Pike	739	5	1
Pulaski	856	6	2
Reynolds	743	8	11
Ripley	667	59	79
Saint Charles	1,423	10	3
Saint Francois	881	6	2
Sainte Genevieve	613	4	1
Saint Louis	2,994	24	15
Saint Louis City	696	37	128
Scott	674	2,300	1,830
Shannon	982	7	2
Stoddard	1,153	2,703	3,369
Texas	1,433	10	3
Warren	670	5	1
Washington	979	7	2
Wayne	817	57	166

Table 268: Highway Bridge Damage

Counties	# Bridges	None	Slight	Moderate	Extensive	Complete
Audrain	287	0.99	0.01	0.00	0.00	0.00
Bollinger	117	0.73	0.06	0.04	0.08	0.09
Boone	256	0.97	0.02	0.01	0.00	0.00
Butler	251	0.25	0.08	0.08	0.16	0.43
Callaway	273	0.99	0.01	0.00	0.00	0.00
Cape Girardeau	323	0.80	0.07	0.03	0.05	0.05
Carter	30	0.87	0.04	0.03	0.03	0.02
Cole	154	0.99	0.01	0.00	0.00	0.00
Crawford	101	0.98	0.01	0.00	0.00	0.00
Dent	73	0.98	0.01	0.00	0.00	0.00
Douglas	67	0.97	0.02	0.01	0.00	0.00
Dunklin	206	0.11	0.05	0.05	0.14	0.64
Franklin	273	0.98	0.01	0.00	0.00	0.00
Gasconade	127	0.98	0.01	0.00	0.00	0.00
Howell	145	0.98	0.01	0.00	0.00	0.00
Iron	105	0.98	0.01	0.00	0.00	0.00
Jefferson	330	0.99	0.01	0.00	0.00	0.00
Lincoln	161	0.99	0.01	0.00	0.00	0.00
Madison	103	0.94	0.05	0.00	0.01	0.00
Maries	64	0.96	0.02	0.01	0.00	0.00
Miller	113	0.97	0.02	0.01	0.00	0.00
Mississippi	91	0.54	0.07	0.05	0.06	0.28
Montgomery	162	0.99	0.01	0.00	0.00	0.00
New Madrid	274	0.14	0.05	0.05	0.13	0.62
Oregon	76	0.91	0.08	0.00	0.00	0.00
Osage	83	0.98	0.01	0.01	0.00	0.00
Ozark	81	0.98	0.01	0.00	0.00	0.00
Pemiscot	192	0.17	0.06	0.06	0.14	0.56
Perry	118	0.95	0.02	0.00	0.00	0.02
Phelps	117	0.97	0.02	0.01	0.00	0.00
Pike	181	0.98	0.01	0.00	0.00	0.00
Pulaski	74	0.99	0.01	0.00	0.00	0.00
Reynolds	72	0.98	0.01	0.00	0.00	0.00
Ripley	114	0.54	0.10	0.08	0.12	0.16
Saint Charles	216	0.99	0.01	0.00	0.00	0.00
Saint Francois	143	0.97	0.02	0.01	0.00	0.00
Sainte Genevieve	79	0.97	0.01	0.00	0.01	0.00
Saint Louis	705	0.98	0.01	0.00	0.00	0.00
Saint Louis City	240	0.91	0.01	0.00	0.05	0.04
Scott	172	0.49	0.06	0.06	0.10	0.28
Shannon	50	0.97	0.02	0.00	0.00	0.00
Stoddard	412	0.20	0.07	0.07	0.14	0.52
Texas	148	0.98	0.01	0.00	0.00	0.00
Warren	110	0.99	0.01	0.00	0.00	0.00
Washington	146	0.98	0.01	0.00	0.00	0.00
Wayne	188	0.61	0.14	0.06	0.09	0.09

Table 269: Highway Bridge Functionality

Counties	No. Bridges	At Day 1 (%)	At Day 3 (%)	At Day 7 (%)	At Day 30 (%)	At Day 90 (%)
Audrain	287	99.42	99.67	99.77	99.78	99.84
Bollinger	117	78.86	81.66	83.35	84.35	88.72
Boone	256	98.69	99.31	99.55	99.60	99.76
Butler	251	34.96	39.40	42.64	45.00	55.82
Callaway	273	99.45	99.66	99.75	99.78	99.84
Cape Girardeau	323	86.33	88.87	90.09	90.72	93.40
Carter	30	91.40	93.22	94.20	94.67	96.53
Cole	154	99.49	99.71	99.79	99.80	99.85
Crawford	101	99.27	99.60	99.72	99.75	99.83
Dent	73	99.06	99.50	99.67	99.70	99.80
Douglas	67	98.73	99.35	99.58	99.63	99.77
Dunklin	206	18.36	21.28	23.59	25.92	37.06
Franklin	273	99.26	99.59	99.71	99.74	99.82
Gasconade	127	98.98	99.44	99.63	99.66	99.79
Howell	145	99.17	99.53	99.68	99.71	99.81
Iron	105	99.14	99.56	99.69	99.72	99.82
Jefferson	330	99.23	99.52	99.64	99.67	99.78
Lincoln	161	99.41	99.67	99.76	99.78	99.84
Madison	103	97.54	98.84	99.00	99.08	99.34
Maries	64	98.29	99.08	99.41	99.48	99.70
Miller	113	98.64	99.29	99.54	99.59	99.75
Mississippi	91	61.77	65.00	66.93	68.05	72.84
Montgomery	162	99.57	99.74	99.81	99.82	99.86
New Madrid	274	21.48	24.48	26.76	28.95	39.44
Oregon	76	97.01	99.11	99.30	99.38	99.63
Osage	83	98.85	99.36	99.58	99.63	99.77
Ozark	81	98.99	99.48	99.66	99.69	99.80
Pemiscot	192	24.87	28.35	30.98	33.30	44.24
Perry	118	96.49	97.10	97.25	97.34	97.66
Phelps	117	98.58	99.17	99.43	99.49	99.69
Pike	181	99.16	99.54	99.69	99.72	99.81
Pulaski	74	99.31	99.56	99.70	99.73	99.81
Reynolds	72	98.93	99.29	99.41	99.46	99.68
Ripley	114	64.57	69.37	72.43	74.07	81.06
Saint Charles	216	99.48	99.70	99.78	99.80	99.85
Saint Francois	143	98.59	99.31	99.55	99.60	99.75
Sainte Genevieve	79	98.41	98.80	98.93	99.01	99.38
Saint Louis	705	98.94	99.23	99.34	99.39	99.64
Saint Louis City	240	91.37	91.63	91.86	92.34	95.00
Scott	172	56.48	59.76	62.05	63.61	70.63
Shannon	50	98.94	99.52	99.68	99.71	99.81
Stoddard	412	28.59	32.54	35.42	37.73	48.36
Texas	148	99.07	99.51	99.67	99.70	99.81
Warren	110	99.56	99.74	99.81	99.82	99.86
Washington	146	99.24	99.61	99.73	99.75	99.83
Wayne	188	73.88	79.29	81.79	83.03	88.18

Tennessee – New Madrid Seismic Zone Event

This earthquake impact assessment includes all 95 counties in the State of Tennessee. Tennessee is approximately 42,100 square miles and is bordered by Kentucky and Virginia to the north, Mississippi, Alabama, and Georgia to the south, Missouri and Arkansas to the west, and North Carolina to the east. For the purposes of this analysis, 37 critical counties have been identified in the western portion of the state where shaking is anticipated to be most intense. These 37 counties are the focus of much of the damage assessment included within this document.

- Benton
- Carroll
- Cheatham
- Chester
- Crockett
- Davidson
- Decatur
- Dickson
- Dyer
- Fayette
- Gibson
- Giles
- Hardeman
- Hardin
- Haywood
- Henderson
- Henry
- Hickman
- Houston
- Humphreys
- Lake
- Lauderdale
- Lawrence
- Lewis
- McNairy
- Madison
- Maury
- Montgomery
- Obion
- Perry
- Robertson
- Shelby
- Stewart
- Tipton
- Wayne
- Weakley
- Williamson

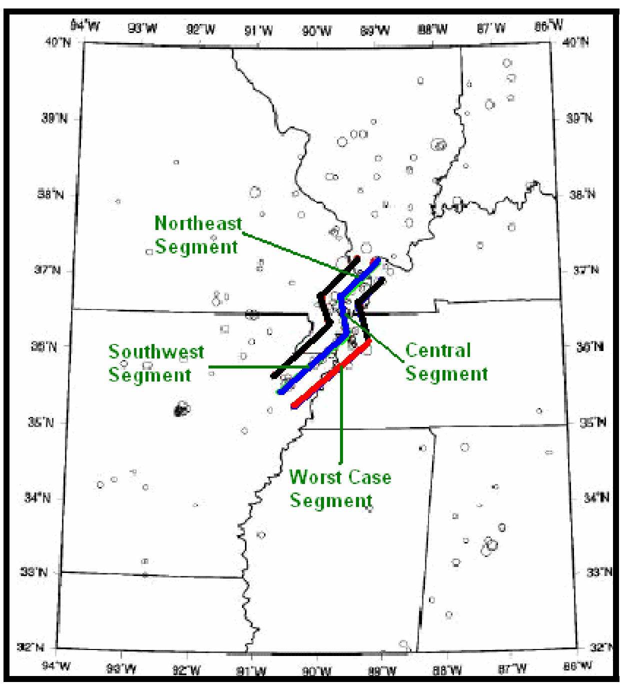

Figure 10: Scenario Fault Location for the State of Tennessee

The earthquake impact assessment for the State of Tennessee employs one scenario event along the New Madrid Seismic Zone (NMSZ). The ground motions used to represent this seismic event were developed by the U.S. Geological Survey (USGS). The scenario

consists of a magnitude 7.7 (M_w7.7) earthquake along one segment of the NMSZ. Each fault line is presumed to consist of three fault segments; northern, central and southern. The worst-case scenario for the State of Tennessee, and the critical counties in particular, is an event on an eastern fault line associated with the southern segment. The location of this scenario event is illustrated in Figure 10. For more information on the hazard utilized in this scenario please reference Appendix I.

The NMSZ scenario produces thousands of damaged buildings in the State of Tennessee. The damage estimates shown indicate that more than 8% of the building stock, roughly 176,000 buildings, experience at least moderate damage. This includes complete damages, which equate to about 4% of the building stock, or roughly 82,000 buildings in Tennessee. Nearly 95% of all cases of complete damage occur with residential buildings. This occupancy type also accounts for nearly 99% of at least moderate damage throughout the state. All of the complete damage cases are contained in the 37 critical counties for the State of Tennessee.

Table 270: Damage by General Occupancy Type for the State of Tennessee

General Occupancy Type Damage (State level)			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	1,720,196	142,729	58,255
Other Residential	330,518	31,012	19,340
Commercial	20,582	1,882	3,461
Industrial	3,553	286	520
Other	2,337	170	331
Total	2,077,186	176,079	81,907

Table 271: Damage by General Occupancy Type for the 37 Critical Counties

General Occupancy Type Damage (37 Critical Counties)			
General Occupancy Type	Total No. Buildings	Moderate to Severe Damage	Complete Damage
Single Family	811,843	142,431	58,255
Other Residential	117,912	28,995	19,340
Commercial	11,113	1,853	3,461
Industrial	1,467	278	520
Other	1,245	167	331
Total	943,580	173,724	81,907

Wood construction, the most prevalent building type in Tennessee, sustains the most cases of complete damage. Nearly 43% of all instances of complete damage, roughly 34,900 buildings, occur with wood frame structures for the State of Tennessee. Unreinforced masonry (URM) construction and mobile homes (MH) also show high frequencies of collapse and account for nearly 54% of all building collapses. The remaining building types show far less inventory throughout the state and thus experience a far lesser proportion of damage.

Table 272: Building Damage by Building Type for the State of Tennessee

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,255,670	180,779	112,188	19,319	34,888
Steel	6,045	222	171	353	1,610
Concrete	1,786	39	68	135	417
Precast	1,934	57	66	139	497
Reinforced Masonry	1,125	15	36	84	312
Unreinforced Masonry	138,979	7,893	7,597	11,117	29,385
Mobile Home	199,367	25,289	13,577	11,229	14,797
Total	1,604,906	214,294	133,703	42,376	81,907

Of the 1,110 fire stations in the state, 256 (more than 23%) are estimated to experience at least moderate damage. Approximately 25-30% of most other essential facility types (schools, hospitals and police stations) each sustain at least moderate damage. In addition, 404 of the 2,309 schools and 117 fire stations are estimated to collapse. The Tennessee inventory does not specify any locations for emergency operations centers and thus no damage can be determined for this type of essential facility.

All non-functional facilities are located in the western portion of the state. Of Tennessee's 180 hospitals, 132 are considered functional the day after the earthquake and that number increases to 137 functional facilities after one week. Roughly 70% of all fire stations and police stations in Tennessee are estimated to remain functional the day after the earthquake, though all these functioning facilities are in the central and eastern portions of the state. Most of Tennessee's western counties are left without functioning facilities and will likely experience diminished services in the immediate aftermath of an earthquake.

Table 273: Essential Facilities Damage & Functionality for the State of Tennessee[10]

Essential Facilities Damage & Functionality (State)				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
Hospitals	180	43	8	132
Schools	2,309	602	404	1,674
EOCs	0	0	0	0
Police Stations	423	124	78	289
Fire Stations	1,110	256	117	815

[10] For Tables 273-283 the following method is used to determine the number of facilities in a damage category. HAZUS-MH MR2 assigns each facility a probability of reaching a specific damage level (at least moderate, complete, etc.). In order to provide quantities of facilities at various damage levels, all those facilities that experience a damage probability of 50% or greater for a given damage level are counted as 'damaged'. Therefore, the facilities that are not 50% likely to incur damage at a specific damage level are deemed 'undamaged'.

Table 274: Essential Facilities Damage & Functionality for the 37 Critical Counties

Essential Facilities Damage & Functionality (37 Critical Counties)				
Essential Facility Type	Total No. Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
Hospitals	81	43	8	33
Schools	1,106	602	404	471
EOCs	0	0	0	0
Police Stations	209	124	78	75
Fire Stations	482	256	117	186

Table 275: Highway Bridge Damage Assessments

Highway Bridge Damage Assessments				
	Total No. Of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
37 Critical Counties	3,815	877	330	2,937
Remaining Counties	3,400	1	0	3,400
Total State	7,215	878	330	6,337

Table 276: Airport Damage Assessments

Airport Damage Assessments				
	Total No. Of Airports	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
37 Critical Counties	141	50	2	104
Remaining Counties	174	0	0	174
Total State	315	50	2	278

As is the case with essential facilities, western Tennessee counties incur the most severe damage. Roughly 900 of the 7,200, or more than 12% of all bridges, are estimated to incur at least moderate damage. Of the nearly 900 damaged bridges, 330 are expected to collapse. Highway road segments connecting these damaged bridges are expected to incur slightly less damage than the bridges themselves, even in the counties with the most severe shaking. Highway segments are most generally defined as a section of highway between two end nodes. These end nodes are frequently highway bridges. At least moderate damage to highway bridges is characterized by moderate shear (diagonal) cracking of columns, spalling of cover concrete and shear keys, abutment movement less than two-inches, extensive cracking to shear keys, bent connection bolts, and moderate settlement of the bridge approaches.

Furthermore, 81 ports, 54 railway facilities, and 50 airports reach at least moderate damage state and follow roughly the same damage distribution throughout the state as highway bridges. At least moderate damage to port facilities includes considerable ground settlement, derailment of port equipment, and damage to structural members. For airports, at least moderate damage is defined in the same manner as damage to other

building types discussed previously. The lack of functionality of many transportation lifelines in western Tennessee will make the movement of people and supplies difficult in the days immediately following the earthquake.

Table 277: Transportation System Damage for the State of Tennessee

Transportation System Damage					
Transportation System	**Type**	**Quantity**	**At Least Moderate Damage (Damage>50%)**	**Complete Damage (Damage >50%)**	**Functionality at Day 1 < 50%**
Highway	Segments	4,682	0	0	4,682
	Bridges	7,215	878	330	6,337
	Tunnels	5	0	0	5
Railways	Segments	2,936	0	0	2,936
	Bridges	151	4	0	147
	Tunnels	15	0	0	15
	Facilities	129	54	1	78
Bus	Facilities	51	7	0	46
Light Rail	Segments	35	0	0	35
	Bridges	0	0	0	0
	Facilities	25	25	25	0
Ferry	Facilities	6	6	6	0
Port	Facilities	200	81	7	129
Airport	Facilities	315	50	2	278
	Runways	206	0	0	206

Table 278: Damage to Potable Water Facilities

Potable Water Facilities Damage Assessments				
	Total No. of Potable Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
37 Critical Counties	30	9	1	21
Remaining Counties	68	0	0	68
Total State	98	9	1	89

Table 279: Damage to Waste Water Facilities

Waste Water Facilities Damage Assessments				
	Total No. of Waste Water Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage >50%)**	**Functionality >50% at Day 1**
37 Critical Counties	742	375	14	246
Remaining Counties	1,204	0	0	1,204
Total State	1,946	375	14	1,450

Utility lifelines show similar damage and functionality estimates to those of the transportation systems. Approximately 380 waste water facilities, 3,500 communication facilities and 65 electric power facilities incur at least moderate damage. Furthermore, 14

waste water facilities and 48 communication facilities are expected to experience complete damage. At least moderated damage to potable water, waste water, communication, electric power, natural gas, and oil facilities are contained within the 37 critical counties. Approximately 49% of all natural gas facilities in the critical counties incur at least moderate damage.

Table 280: Damage to Natural Gas Facilities

Natural Gas Facilities Damage Assessments				
	Total No. of Natural Gas Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
37 Critical Counties	121	59	1	62
Remaining Counties	62	0	0	62
Total State	183	59	1	124

Table 281: Damage to Oil Facilities

Oil Facilities Damage Assessments				
	Total No. of Oil Facilities	At Least Moderate Damage (Damage > 50%)	Complete Damage (Damage > 50%)	Functionality >50% at Day 1
37 Critical Counties	65	32	0	33
Remaining Counties	56	0	0	56
Total State	121	32	0	89

Table 282: Damage to Electric Power Facilities

Electric Power Facilities Damage Assessments				
	Total No. of Electric Power Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
37 Critical Counties	153	63	0	61
Remaining Counties	275	0	0	275
Total State	428	63	0	336

Table 283: Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% at Day 1
37 Critical Counties	6,969	3,468	48	5,018
Remaining Counties	9,161	0	0	9,161
Total State	16,130	3,468	48	14,179

Pipeline damage is estimated for local potable water, waste water and natural gas systems. Major transmission pipelines for natural gas are added from HSIP 2007 data. Oil pipelines are not included in the HAZUS-MH MR2 default inventory, called local

inventory in HAZUS-MH MR2, though regional oil pipelines are added to provide damage estimates for these major oil transmission lines. These oil pipelines are composed of major crude oil and refined product lines only. Regional and local natural gas networks are represented separately and damage is estimated for each. Potable water lines show the greatest amount of leaks and breaks at 18,910 and 12,334, respectively. Local natural gas lines, however, show the greatest leak and break rates per length of pipe at roughly 0.34 leaks/mile (1 leak every 3 miles) and roughly 0.22 breaks/mile (roughly 1 break every 4.5 miles). In addition, local and regional damage to natural gas lines can be combined for a total state damage estimate of 16,219 leaks and 11,015 breaks over the combined length of 51,582 miles of natural gas pipeline.

Potable water service is cut off for nearly 447,000 residences the day after the scenario earthquake. This is reduced to roughly 408,000 residences within a week. Even after three months, service has not been restored for nearly 165,000 residences. These estimates are calculated from a formula that uses the damage to the distribution system to determine the repair rate. Additional information on this formula is available in the HAZUS-MH MR2 Technical Manual that accompanies the program. This period of time without water prevents thousands of people from remaining in their homes in the weeks and months following the earthquake. Electric power service shows similar trends, with over 426,000, or nearly 20%, of all residences without electric power the day after the earthquake. Even a month after the earthquake, nearly 38,000 residences are still without power. All electric power lines in Tennessee are presumed to be above ground and less likely to incur damage from moderate ground shaking, unlike buried pipelines that are vulnerable to damage from liquefaction and ground deformation.

Table 284: Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water - Local	117,443	18,910	12,334
Waste Water - Local	70,466	14,956	9,755
Natural Gas - Regional	4,605	232	587
Natural Gas - Local	46,977	15,987	10,428
Oil - Regional	1,018	53	127

Table 285: Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Potable Water	2,232,905	446,891	433,647	408,112	360,553	164,750
Electric Power		426,573	296,249	146,276	37,717	508

The infrastructure damage in HAZUS-MH MR2 is evaluated based on a percentage of reaching a specified damage level. There are various methods available to quantify damage based on the likelihoods of reaching the four damage levels available in HAZUS-MH MR2. Two different methods are employed in this report and are discussed herein.

Some of the following damage tables depict damage at the county level for essential, transportation, and utility facilities. This is the format employed to generate the HAZUS-MH MR2 summary reports for various types of infrastructure and networks. The damage state likelihoods (shown as percentages) represent the **average** damage state likelihoods for all facilities of a given type in a specific county. The damage estimates shown previously for corresponding infrastructure types are based on a different set of criteria as discussed in footnote (10) and employed in the preceding damage tables for this scenario. Both methods are employed in HAZUS-MH MR2 and are valid estimation methodologies, though they generate different estimations of county damage for a specific facility type. Consider the following comparison:

- Shelby County, Tennessee – 117 waste water facilities
    - Estimation procedure according to footnote 10:
        - Summation of individual facilities after that facility is deemed 'damaged' or 'undamaged' based on 50% or greater damage likelihood requirement estimates **117 at least moderately damaged waste water facilities**
    - Estimation procedure according to topic damage tables in this appendix:
        - To determine the percentage of waste water facilities in the at least moderate damage category, add the percentages for moderate, extensive and complete damage for the county then multiply by the number of facilities in that county
        - Using these damage state probabilities averaged over all the facilities in the county provides an estimate of **97 at least moderately damaged waste water facilities**

In the case of Shelby County, Tennessee, the topic damage tables in this appendix provide a lower estimate of damage as opposed to the facility-by-facility damage summation detailed in footnote (10). Though not illustrated here, other counties in Tennessee are estimated to incur greater damage when this averaging estimation procedure is used. Comparing the total number of at least moderately damaged waste water facilities for the 37 critical counties in Tennessee shows the following:

- Total number of at least moderately damaged waste water facilities according to the HAZUS-MH MR2 procedure for averaging damage at the county level
    - **366 at least moderately damaged waste water facilities**
- Total number of at least moderately damaged waste water facilities according to the other HAZUS-MH MR2 method of assessing facility-by-facility damage
    - **375 at least moderately damaged waste water facilities**

Comparing damage estimates for these two methods clearly shows that the averaging procedure produces less damage. Other infrastructure categories may or may not follow

this trend thus requiring an investigation of each infrastructure type separately. This is not undertaken here, though it can be done with the information provided in this appendix.

The following tables provide damage and functionality estimates for the NMSZ scenario critical counties in Tennessee. There tables employ the HAZUS-MH MR2 damage methodology of averaging each of four damage levels for a county.

Table 286: Building Damage by General Occupancy

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Benton						
Single Family	4,161	826	85	5	9	5,086
Other Residential	1,078	904	504	13	7	2,506
Commercial	14	6	3	0	0	23
Industrial	0	0	0	0	0	0
Other	1	0	0	0	0	1
Carroll						
Single Family	1,824	4,233	2,239	319	310	8,925
Other Residential	54	340	1,099	1,035	241	2,769
Commercial	1	8	24	18	6	57
Industrial	0	1	7	9	3	20
Other	0	1	1	1	0	3
Cheatham						
Single Family	11,305	60	4	0	0	11,369
Other Residential	2,156	204	25	0	0	2,385
Commercial	34	1	0	0	0	35
Industrial	4	0	0	0	0	4
Other	6	0	0	0	0	6
Chester						
Single Family	1,843	1,710	421	114	60	4,148
Other Residential	52	169	556	540	100	1,417
Commercial	1	3	9	7	2	22
Industrial	0	0	1	2	1	4
Other	1	2	3	2	0	8
Crockett						
Single Family	483	1,898	1,358	295	527	4,561
Other Residential	6	28	96	229	502	861
Commercial	0	0	2	7	24	33
Industrial	0	0	0	1	6	7
Other	0	0	0	0	7	7
Davidson						
Single Family	159,343	844	52	1	0	160,240
Other Residential	16,555	494	55	0	0	17,104
Commercial	3,658	93	11	0	0	3,762
Industrial	356	10	1	0	0	367
Other	412	10	1	0	0	423
Decatur						
Single Family	2,629	1,081	212	47	10	3,980
Other Residential	384	377	450	278	44	1,533
Commercial	9	4	3	1	0	17
Industrial	2	1	1	0	0	4
Other	2	1	0	0	0	3

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Dickson						
Single Family	13,021	69	4	0	0	13,094
Other Residential	2,971	264	32	0	0	3,268
Commercial	138	4	0	0	0	142
Industrial	17	0	0	0	0	17
Other	13	0	0	0	0	13
Dyer						
Single Family	3	58	1,264	4,513	5,910	11,748
Other Residential	0	0	46	213	1,653	1,912
Commercial	0	0	0	2	119	121
Industrial	0	0	0	0	29	29
Other	0	0	0	1	18	19
Fayette						
Single Family	1,793	3,844	2,210	388	534	8,769
Other Residential	16	130	586	746	504	1,982
Commercial	1	4	13	11	7	36
Industrial	0	2	10	14	8	34
Other	0	1	1	1	0	3
Gibson						
Single Family	476	3,246	6,603	2,557	2,140	15,022
Other Residential	20	139	520	760	1,218	2,657
Commercial	1	4	22	35	62	124
Industrial	0	0	3	6	18	27
Other	0	1	3	3	9	16
Giles						
Single Family	9,569	51	3	0	0	9,623
Other Residential	2,167	188	23	0	0	2,378
Commercial	70	2	0	0	0	72
Industrial	11	0	0	0	0	11
Other	5	0	0	0	0	5
Hardeman						
Single Family	2,820	2,882	835	194	180	6,911
Other Residential	74	283	970	942	202	2,471
Commercial	1	8	21	15	5	50
Industrial	0	0	1	1	0	2
Other	1	2	4	4	1	12
Hardin						
Single Family	6,835	1,257	130	9	381	8,612
Other Residential	1,120	898	495	13	80	2,606
Commercial	27	12	5	0	4	48
Industrial	9	4	3	0	2	18
Other	5	2	0	0	0	7

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Haywood						
Single Family	86	1,324	2,758	590	487	5,245
Other Residential	4	63	244	333	433	1,077
Commercial	0	1	8	16	23	47
Industrial	0	0	1	7	30	38
Other	0	0	0	2	2	4
Henderson						
Single Family	3,125	2,898	713	192	450	7,378
Other Residential	94	355	1,229	1,197	419	3,294
Commercial	2	11	31	23	7	74
Industrial	0	1	4	5	1	11
Other	1	2	6	5	1	15
Henry						
Single Family	4,828	3,418	909	211	262	9,628
Other Residential	806	896	1,285	932	256	4,175
Commercial	3	12	34	25	9	83
Industrial	0	1	5	5	2	13
Other	1	1	2	1	1	6
Hickman						
Single Family	5,695	30	2	0	0	5,727
Other Residential	2,073	201	25	0	0	2,299
Commercial	22	1	0	0	0	23
Industrial	3	0	0	0	0	3
Other	10	0	0	0	0	10
Houston						
Single Family	2,238	115	12	1	0	2,366
Other Residential	718	235	110	2	0	1,065
Commercial	10	0	0	0	0	10
Industrial	0	0	0	0	0	0
Other	4	0	0	0	0	4
Humphreys						
Single Family	5,261	559	58	2	0	5,880
Other Residential	1,249	536	267	6	0	2,058
Commercial	26	10	4	0	0	40
Industrial	1	1	0	0	0	2
Other	4	1	0	0	0	5
Lake						
Single Family	711	359	208	38	271	1,587
Other Residential	112	22	40	65	133	372
Commercial	3	0	0	1	1	5
Industrial	0	0	0	0	0	0
Other	0	0	0	2	3	5

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Lauderdale						
Single Family	13	267	1,608	2,390	2,565	6,843
Other Residential	0	12	91	138	1,604	1,845
Commercial	0	0	0	1	39	40
Industrial	0	0	0	0	10	10
Other	0	0	1	1	12	14
Lawrence						
Single Family	12,171	64	4	0	0	12,239
Other Residential	2,219	196	24	0	0	2,439
Commercial	75	2	0	0	0	77
Industrial	16	0	0	0	0	16
Other	18	0	0	0	0	18
Lewis						
Single Family	3,103	16	1	0	0	3,120
Other Residential	1,132	107	13	0	0	1,252
Commercial	14	0	0	0	0	14
Industrial	0	0	0	0	0	0
Other	2	0	0	0	0	2
Madison						
Single Family	4,298	13,057	7,493	997	1,693	27,538
Other Residential	224	993	1,563	1,137	420	4,337
Commercial	10	63	182	134	67	456
Industrial	1	5	23	28	11	68
Other	2	8	15	12	7	43
Maury						
Single Family	21,758	115	7	0	0	21,880
Other Residential	3,959	317	39	0	0	4,315
Commercial	209	5	1	0	0	215
Industrial	46	1	0	0	0	47
Other	31	1	0	0	0	32
McNairy						
Single Family	4,382	2,510	558	144	97	7,691
Other Residential	373	427	709	549	107	2,165
Commercial	11	9	15	9	3	47
Industrial	17	9	8	5	1	40
Other	2	2	2	2	0	8
Montgomery						
Single Family	38,659	205	13	0	0	38,877
Other Residential	4,971	341	41	0	0	5,353
Commercial	363	9	1	0	0	373
Industrial	18	0	0	0	0	18
Other	36	1	0	0	0	37

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Obion						
Single Family	2,043	3,911	1,951	315	1,452	9,672
Other Residential	81	146	276	648	1,411	2,562
Commercial	0	2	15	30	57	104
Industrial	0	0	1	2	6	9
Other	0	1	2	4	11	18
Perry						
Single Family	1,953	387	40	2	0	2,382
Other Residential	549	461	258	6	0	1,274
Commercial	13	6	3	0	0	22
Industrial	3	2	1	0	0	6
Other	2	1	0	0	0	3
Robertson						
Single Family	16,944	90	6	0	0	17,040
Other Residential	2,729	234	29	0	0	2,992
Commercial	121	3	0	0	0	124
Industrial	37	1	0	0	0	38
Other	8	0	0	0	0	8
Shelby						
Single Family	32,859	118,257	72,880	10,924	36,411	271,331
Other Residential	1,236	4,779	3,075	1,643	6,558	17,291
Commercial	1	12	232	836	2,921	4,002
Industrial	0	1	22	92	348	463
Other	9	37	33	43	233	354
Stewart						
Single Family	3,383	518	108	25	5	4,039
Other Residential	779	236	299	223	36	1,573
Commercial	8	3	2	1	0	14
Industrial	2	1	1	0	0	4
Other	2	0	0	0	0	2
Tipton						
Single Family	136	1,827	6,431	3,230	3,793	15,417
Other Residential	1	18	112	241	2,763	3,135
Commercial	0	0	0	3	81	84
Industrial	0	0	0	0	34	34
Other	0	0	2	2	24	28
Wayne						
Single Family	3,672	98	10	0	0	3,780
Other Residential	1,527	266	90	2	0	1,885
Commercial	31	1	0	0	0	32
Industrial	21	1	0	0	0	22
Other	10	0	0	0	0	10

Counties	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
Weakley						
Single Family	982	4,117	3,176	546	708	9,529
Other Residential	63	332	849	959	649	2,852
Commercial	0	3	14	21	24	62
Industrial	0	0	2	6	10	18
Other	0	1	3	3	2	8
Williamson						
Single Family	50,285	266	16	0	0	50,567
Other Residential	2,265	169	20	0	0	2,454
Commercial	605	15	2	0	0	622
Industrial	61	2	0	0	0	63
Other	82	2	0	0	0	84

Table 287: Hospital Functionality

Counties	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
Benton	93	44	47.30	45	47.90	68	73.30	91	97.60	92	98.80
Carroll	135	1	0.40	1	0.40	4	2.60	39	29.20	76	56.10
Cheatham	29	28	96.40	28	96.50	29	99.30	29	99.90	29	99.90
Chester	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Crockett	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Davidson	5,307	5116	96.40	5121	96.50	5270	99.30	5302	99.90	5302	99.90
Decatur	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dickson	150	145	96.40	145	96.50	149	99.30	150	99.90	150	99.90
Dyer	225	0	0.00	0	0.00	0	0.00	2	1.10	35	15.50
Fayette	50	0	0.40	0	0.40	1	2.60	15	29.20	28	56.10
Gibson	235	0	0.13	0	0.13	2	0.87	24	10.30	56	23.73
Giles	95	92	96.40	92	96.50	94	99.30	95	99.90	95	99.90
Hardeman	308	1	0.40	1	0.40	8	2.60	90	29.10	173	56.10
Hardin	131	62	47.30	63	47.90	96	73.30	128	97.60	129	98.80
Haywood	62	0	0.00	0	0.00	0	0.00	1	2.00	9	13.80
Henderson	52	0	0.40	0	0.50	1	2.70	16	29.90	30	57.60
Henry	317	1	0.40	2	0.50	9	2.70	95	29.90	183	57.60
Hickman	84	81	96.40	81	96.50	83	99.30	84	99.90	84	99.90
Houston	40	39	96.40	39	96.50	40	99.30	40	99.90	40	99.90
Humphreys	52	25	47.70	25	48.30	38	73.60	51	97.60	51	98.80
Lake	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lauderdale	70	0	0.00	0	0.00	0	0.00	1	1.10	11	15.50
Lawrence	107	103	96.40	103	96.50	106	99.30	107	99.90	107	99.90
Lewis	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Madison	876	4	0.40	4	0.40	23	2.60	255	29.10	489	55.88
Maury	255	246	96.40	246	96.50	253	99.30	255	99.90	255	99.90
McNairy	86	0	0.40	0	0.50	2	2.70	26	29.90	50	57.60
Montgomery	314	303	96.40	303	96.50	312	99.30	314	99.90	314	99.90
Obion	173	9	5.10	10	5.60	44	25.30	141	81.40	152	88.00
Perry	53	25	47.30	25	47.90	39	73.30	52	97.60	52	98.80
Robertson	100	96	96.40	97	96.50	99	99.30	100	99.90	100	99.90
Shelby	5,323	232	4.36	256	4.80	1165	21.88	3935	73.92	4377	82.23
Stewart	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tipton	110	0	0.00	0	0.00	0	0.00	1	1.20	17	15.50
Wayne	80	77	96.40	77	96.50	79	99.30	80	99.90	80	99.90
Weakley	140	0	0.00	0	0.00	0	0.00	3	2.00	19	13.80
Williamson	299	288	96.40	289	96.50	297	99.30	299	99.90	299	99.90

Table 288: Police Station Functionality

Counties	Count	Functionality At Day 1 (%)
Benton	3	47.00
Carroll	6	0.80
Cheatham	3	94.10
Chester	2	0.80
Crockett	4	0.00
Davidson	23	94.10
Decatur	3	16.27
Dickson	4	94.10
Dyer	7	0.00
Fayette	7	0.54
Gibson	9	0.18
Giles	5	94.10
Hardeman	5	0.80
Hardin	3	46.87
Haywood	2	0.00
Henderson	3	0.80
Henry	4	0.80
Hickman	2	94.10
Houston	2	94.10
Humphreys	4	61.23
Lake	3	0.00
Lauderdale	5	0.00
Lawrence	6	94.10
Lewis	2	94.10
Madison	3	0.80
Maury	4	94.10
McNairy	4	12.25
Montgomery	5	94.10
Obion	7	1.00
Perry	1	47.00
Robertson	5	94.10
Shelby	39	0.18
Stewart	3	51.90
Tipton	6	0.00
Wayne	4	83.55
Weakley	7	0.34
Williamson	4	94.10

Table 289: School Functionality

Counties	Count	Functionality At Day 1 (%)
Benton	10	47.00
Carroll	18	0.80
Cheatham	15	94.10
Chester	11	0.78
Crockett	7	0.00
Davidson	205	94.10
Decatur	4	23.95
Dickson	19	94.10
Dyer	17	0.00
Fayette	14	0.56
Gibson	21	0.08
Giles	11	94.10
Hardeman	14	0.79
Hardin	13	47.97
Haywood	8	0.00
Henderson	13	0.80
Henry	10	4.25
Hickman	10	94.10
Houston	5	85.66
Humphreys	10	68.29
Lake	3	0.00
Lauderdale	10	0.00
Lawrence	19	94.10
Lewis	7	94.10
Madison	44	0.79
Maury	26	94.10
McNairy	12	16.05
Montgomery	50	94.10
Obion	11	1.27
Perry	5	47.00
Robertson	22	94.10
Shelby	361	0.12
Stewart	4	60.25
Tipton	14	0.00
Wayne	10	85.66
Weakley	16	0.32
Williamson	57	94.10

Table 290: Fire Station Functionality

Counties	Count	Functionality At Day 1 (%)
Benton	10	46.92
Carroll	11	0.80
Cheatham	11	94.10
Chester	10	0.80
Crockett	7	0.00
Davidson	37	94.10
Decatur	8	29.71
Dickson	12	94.10
Dyer	6	0.00
Fayette	13	0.54
Gibson	12	0.20
Giles	12	94.10
Hardeman	12	0.78
Hardin	3	46.87
Haywood	5	0.00
Henderson	14	0.80
Henry	17	19.73
Hickman	7	94.10
Houston	2	73.00
Humphreys	9	60.73
Lake	2	0.00
Lauderdale	7	0.00
Lawrence	18	94.10
Lewis	1	94.10
Madison	22	0.77
Maury	12	94.10
McNairy	22	13.27
Montgomery	18	94.10
Obion	10	1.40
Perry	7	47.00
Robertson	13	94.10
Shelby	73	0.29
Stewart	5	67.02
Tipton	10	0.00
Wayne	10	81.44
Weakley	12	0.38
Williamson	22	94.10

Table 291: Communication Functionality

Counties	# of Facilities	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Benton	64	78.20	93.75	95.85	99.31	99.86
Carroll	96	66.91	86.89	90.73	98.07	99.63
Cheatham	71	93.55	98.96	99.43	99.90	99.90
Chester	35	77.66	93.09	95.19	98.80	99.76
Crockett	75	44.15	65.74	74.02	92.65	98.64
Davidson	1,205	99.50	99.90	99.90	99.90	99.90
Decatur	35	78.40	94.00	96.10	99.50	99.90
Dickson	138	93.27	98.91	99.40	99.90	99.90
Dyer	159	23.46	34.01	43.96	72.48	95.08
Fayette	129	59.33	80.37	85.62	96.47	99.33
Gibson	245	36.00	54.25	63.66	86.70	97.60
Giles	104	99.50	99.90	99.90	99.90	99.90
Hardeman	94	71.99	89.86	92.90	98.48	99.70
Hardin	107	78.32	93.90	96.00	99.42	99.89
Haywood	99	38.99	59.50	68.79	90.38	98.26
Henderson	101	74.52	91.68	94.38	99.13	99.83
Henry	120	75.63	92.19	94.69	99.04	99.80
Hickman	76	93.20	98.90	99.40	99.90	99.90
Houston	24	86.42	96.65	97.89	99.72	99.90
Humphreys	83	86.78	96.77	97.97	99.73	99.90
Lake	35	47.15	66.55	72.46	86.93	97.64
Lauderdale	110	23.51	34.10	44.15	72.81	95.12
Lawrence	143	96.11	99.36	99.63	99.90	99.90
Lewis	38	93.20	98.90	99.40	99.90	99.90
Madison	394	60.11	81.55	86.61	96.85	99.39
Maury	163	97.76	99.62	99.76	99.90	99.90
McNairy	95	78.26	93.83	95.93	99.37	99.87
Montgomery	252	93.20	98.90	99.40	99.90	99.90
Obion	192	49.36	69.89	76.57	91.79	98.50
Perry	56	87.08	96.84	98.00	99.70	99.89
Robertson	151	99.50	99.90	99.90	99.90	99.90
Shelby	1,596	45.45	66.56	74.34	92.01	98.54
Stewart	51	87.40	96.98	98.11	99.74	99.90
Tipton	121	26.80	39.96	50.13	77.58	96.00
Wayne	63	93.20	98.90	99.40	99.90	99.90
Weakley	139	48.80	70.86	78.13	94.04	98.89
Williamson	310	98.73	99.78	99.84	99.90	99.90

Table 292: Households without Potable Water Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Benton	6,863	0.00	0.00	0.00	0.00	0.00
Carroll	11,779	10.61	0.42	0.00	0.00	0.00
Cheatham	12,878	0.00	0.00	0.00	0.00	0.00
Chester	5,660	0.00	0.00	0.00	0.00	0.00
Crockett	5,632	86.65	80.43	53.46	0.00	0.00
Davidson	237,405	0.00	0.00	0.00	0.00	0.00
Decatur	4,908	0.00	0.00	0.00	0.00	0.00
Dickson	16,473	0.00	0.00	0.00	0.00	0.00
Dyer	14,751	99.69	99.67	99.59	98.46	0.00
Fayette	10,467	43.50	31.31	4.80	0.00	0.00
Gibson	19,518	96.66	96.24	95.17	71.88	0.00
Giles	11,713	0.00	0.00	0.00	0.00	0.00
Hardeman	9,412	2.08	0.00	0.00	0.00	0.00
Hardin	10,426	4.99	0.00	0.00	0.00	0.00
Haywood	7,558	77.84	72.03	54.02	0.00	0.00
Henderson	10,306	63.78	53.90	24.86	0.00	0.00
Henry	13,019	13.84	1.55	0.00	0.00	0.00
Hickman	8,081	0.00	0.00	0.00	0.00	0.00
Houston	3,216	0.00	0.00	0.00	0.00	0.00
Humphreys	7,238	0.00	0.00	0.00	0.00	0.00
Lake	2,410	97.84	96.56	89.71	0.00	0.00
Lauderdale	9,567	99.70	99.66	99.57	97.76	0.00
Lawrence	15,480	0.00	0.00	0.00	0.00	0.00
Lewis	4,381	0.00	0.00	0.00	0.00	0.00
Madison	35,552	51.73	40.35	11.61	0.00	0.00
Maury	26444	0	0	0	0	0
McNairy	9,980	0.00	0.00	0.00	0.00	0.00
Montgomery	48,330	0	0	0	0	0
Obion	13,182	95.06	94.25	92.1	14.72	0
Perry	3,023	0	0	0	0	0
Robertson	19,906	0	0	0	0	0
Shelby	338,366	94.49	94.27	93.8	89.77	48.7
Stewart	4,930	0	0	0	0	0
Tipton	18,106	99.2	99.1	98.9	93.71	0
Wayne	5,936	0	0	0	0	0
Weakley	13,599	52.53	40.87	11.1	0	0
Williamson	44,725	0	0	0	0	0

Table 293: Potable Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Benton	1	18.35%	39.26%	28.68%	6.10%	7.59%
Carroll	N/A	N/A	N/A	N/A	N/A	N/A
Cheatham	1	50.00%	37.59%	11.35%	0.98%	0.06%
Chester	N/A	N/A	N/A	N/A	N/A	N/A
Crockett	N/A	N/A	N/A	N/A	N/A	N/A
Davidson	5	89.79%	9.43%	0.74%	0.02%	0.00%
Decatur	2	19.73%	42.20%	30.82%	6.56%	0.67%
Dickson	1	50.00%	37.59%	11.35%	0.98%	0.06%
Dyer	2	0.05%	1.38%	12.78%	37.11%	48.66%
Fayette	N/A	N/A	N/A	N/A	N/A	N/A
Gibson	N/A	N/A	N/A	N/A	N/A	N/A
Giles	N/A	N/A	N/A	N/A	N/A	N/A
Hardeman	N/A	N/A	N/A	N/A	N/A	N/A
Hardin	1	19.73%	42.20%	30.82%	6.56%	0.67%
Haywood	N/A	N/A	N/A	N/A	N/A	N/A
Henderson	2	19.73%	42.20%	30.82%	6.56%	0.67%
Henry	N/A	N/A	N/A	N/A	N/A	N/A
Hickman	1	50.00%	37.59%	11.35%	0.98%	0.06%
Houston	N/A	N/A	N/A	N/A	N/A	N/A
Humphreys	N/A	N/A	N/A	N/A	N/A	N/A
Lake	N/A	N/A	N/A	N/A	N/A	N/A
Lauderdale	1	0.04%	1.22%	12.47%	39.93%	46.32%
Lawrence	N/A	N/A	N/A	N/A	N/A	N/A
Lewis	N/A	N/A	N/A	N/A	N/A	N/A
Madison	N/A	N/A	N/A	N/A	N/A	N/A
Maury	2	69.90%	23.51%	6.05%	0.50%	0.03%
McNairy	1	19.73%	42.20%	30.82%	6.56%	0.67%
Montgomery	1	50.00%	37.59%	11.35%	0.98%	0.06%
Obion	N/A	N/A	N/A	N/A	N/A	N/A
Perry	1	50.00%	37.59%	11.35%	0.98%	0.06%
Robertson	N/A	N/A	N/A	N/A	N/A	N/A
Shelby	4	0.03	0.20	0.42	0.27	0.07
Stewart	1	0.50	0.38	0.11	0.01	0.00
Tipton	2	0.00	0.02	0.15	0.40	0.43
Wayne	N/A	N/A	N/A	N/A	N/A	N/A
Weakley	N/A	N/A	N/A	N/A	N/A	N/A
Williamson	1	50.0%	37.6%	11.4%	1.0%	0.1%

Table 294: Potable Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Benton	903	39	12
Carroll	1,288	154	97
Cheatham	823	5	1
Chester	639	29	13
Crockett	624	620	283
Davidson	3,244	18	4
Decatur	794	34	9
Dickson	1,372	8	2
Dyer	1,097	3,239	1,859
Fayette	1,485	305	233
Gibson	1,443	1,283	1,130
Giles	1,576	9	2
Hardeman	1,285	81	62
Hardin	1,363	52	79
Haywood	1,123	550	372
Henderson	1,182	118	282
Henry	1,309	115	109
Hickman	1,379	8	2
Houston	536	10	2
Humphreys	1,114	6	2
Lake	350	129	341
Lauderdale	925	2,941	1,572
Lawrence	1,501	8	2
Lewis	578	3	1
Madison	1,379	227	255
Maury	1,843	10	3
McNairy	1,249	57	26
Montgomery	1,976	11	3
Obion	1,230	987	831
Perry	807	4	1
Robertson	1,382	8	2
Shelby	4,734	4,547	2,991
Stewart	1,096	14	4
Tipton	1,097	2,561	1,399
Wayne	1,352	7	2
Weakley	1,329	332	251
Williamson	1,873	10	3

Table 295: Households without Electric Power Service

Counties	# of Households	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Benton	6,863	0.00	0.00	0.00	0.00	0.00
Carroll	11,779	53.43	27.21	7.58	0.98	0.08
Cheatham	12,878	0.00	0.00	0.00	0.00	0.00
Chester	5,660	0.00	0.00	0.00	0.00	0.00
Crockett	5,632	86.12	60.85	29.44	6.76	0.11
Davidson	237,405	0.00	0.00	0.00	0.00	0.00
Decatur	4,908	0.00	0.00	0.00	0.00	0.00
Dickson	16,473	0.00	0.00	0.00	0.00	0.00
Dyer	14,751	95.20	85.55	63.54	23.70	0.10
Fayette	10,467	77.80	47.24	18.42	3.50	0.10
Gibson	19,518	89.17	67.98	38.01	10.57	0.10
Giles	11,713	0.00	0.00	0.00	0.00	0.00
Hardeman	9,412	36.68	18.68	5.21	0.68	0.05
Hardin	10,426	0.00	0.00	0.00	0.00	0.00
Haywood	7,558	88.67	65.71	33.77	8.02	0.11
Henderson	10,306	9.34	4.75	1.33	0.17	0.01
Henry	13,019	17.69	9.13	2.70	0.45	0.02
Hickman	8,081	0.00	0.00	0.00	0.00	0.00
Houston	3,216	0.00	0.00	0.00	0.00	0.00
Humphreys	7,238	0.00	0.00	0.00	0.00	0.00
Lake	2,410	58.71	40.46	21.99	7.84	0.08
Lauderdale	9,567	94.91	84.37	61.23	22.09	0.10
Lawrence	15,480	0.00	0.00	0.00	0.00	0.00
Lewis	4,381	0.00	0.00	0.00	0.00	0.00
Madison	35,552	75.13	42.52	14.54	2.56	0.10
Maury	26,444	0.00	0.00	0.00	0.00	0.00
McNairy	9,980	0.00	0.00	0.00	0.00	0.00
Montgomery	48,330	0.00	0.00	0.00	0.00	0.00
Obion	13,182	80.76	53.02	25.12	6.93	0.10
Perry	3,023	0.00	0.00	0.00	0.00	0.00
Robertson	19,906	0.00	0.00	0.00	0.00	0.00
Shelby	338,366	84.64	58.32	27.66	6.63	0.10
Stewart	4,930	0.00	0.00	0.00	0.00	0.00
Tipton	18,106	93.78	80.59	55.11	18.73	0.10
Wayne	5,936	0.00	0.00	0.00	0.00	0.00
Weakley	13,599	82.35	53.59	22.44	4.38	0.10
Williamson	44,725	0.00	0.00	0.00	0.00	0.00

Table 296: Waste Water Facility Damage

Counties	# of Facilities	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Benton	18	19.50%	41.71%	30.46%	6.48%	1.82%
Carroll	22	9.57%	33.63%	39.76%	14.03%	3.00%
Cheatham	10	53.98%	34.77%	10.29%	0.88%	0.05%
Chester	6	18.81%	40.24%	29.39%	6.25%	5.28%
Crockett	5	2.0%	14.8%	36.5%	30.7%	16.0%
Davidson	64	89.79%	9.43%	0.74%	0.02%	0.00%
Decatur	12	19.73%	42.20%	30.82%	6.56%	0.67%
Dickson	16	50.00%	37.59%	11.35%	0.98%	0.06%
Dyer	20	0.05%	1.33%	12.62%	37.68%	48.30%
Fayette	18	6.39%	26.38%	38.27%	19.31%	9.63%
Gibson	20	1.04%	10.01%	32.40%	35.28%	21.26%
Giles	15	89.8%	9.4%	0.7%	0.0%	0.0%
Hardeman	18	13.84%	36.73%	35.06%	10.48%	3.88%
Hardin	18	19.27%	41.22%	30.11%	6.41%	2.98%
Haywood	23	0.8%	9.4%	33.2%	36.5%	20.1%
Henderson	13	18.88%	41.50%	31.60%	7.20%	0.81%
Henry	28	15.76%	38.91%	34.43%	9.53%	1.36%
Hickman	9	50.0%	37.6%	11.4%	1.0%	0.1%
Houston	N/A	N/A	N/A	N/A	N/A	N/A
Humphreys	20	30.32%	40.59%	24.01%	4.61%	0.46%
Lake	3	3.01%	18.55%	35.90%	20.47%	22.06%
Lauderdale	15	0.05%	1.35%	12.78%	38.85%	46.94%
Lawrence	9	63.26%	28.20%	7.81%	0.66%	0.04%
Lewis	5	50.00%	37.59%	11.35%	0.98%	0.06%
Madison	29	5.51%	25.24%	39.13%	18.94%	11.16%
Maury	28	74.16%	20.49%	4.91%	0.40%	0.02%
McNairy	10	19.73%	42.20%	30.82%	6.56%	0.67%
Montgomery	22	50.00%	37.59%	11.35%	0.98%	0.06%
Obion	21	2.08%	13.53%	33.21%	29.40%	21.75%
Perry	7	45.68%	38.25%	14.13%	1.78%	0.15%
Robertson	15	89.79%	9.43%	0.74%	0.02%	0.00%
Shelby	117	2.16%	14.88%	35.41%	28.68%	18.84%
Stewart	11	44.50%	38.43%	14.89%	1.99%	0.17%
Tipton	26	0.16%	2.92%	18.50%	39.70%	38.70%
Wayne	7	50.00%	37.59%	11.35%	0.98%	0.06%
Weakley	38	3.17%	19.94%	40.49%	25.12%	11.26%
Williamson	24	84.82%	12.95%	2.07%	0.14%	0.01%

Table 297: Waste Water Pipeline Damage

Counties	Length (miles)	Total Number of Leaks	Total Number of Breaks
Benton	542	31	10
Carroll	773	122	77
Cheatham	494	4	1
Chester	384	23	11
Crockett	374	491	224
Davidson	1,947	14	4
Decatur	476	27	7
Dickson	823	6	1
Dyer	658	2,562	1,471
Fayette	891	241	184
Gibson	866	1,014	894
Giles	946	7	2
Hardeman	771	64	49
Hardin	818	41	63
Haywood	674	435	294
Henderson	709	93	223
Henry	785	91	86
Hickman	827	6	1
Houston	322	8	2
Humphreys	668	5	1
Lake	210	102	269
Lauderdale	555	2,326	1,243
Lawrence	900	6	2
Lewis	347	3	1
Madison	827	180	202
Maury	1,106	8	2
McNairy	750	45	21
Montgomery	1,186	9	2
Obion	738	781	657
Perry	484	3	1
Robertson	829	6	1
Shelby	2,840	3,596	2,366
Stewart	658	11	3
Tipton	658	2,025	1,107
Wayne	811	6	1
Weakley	797	262	198
Williamson	1,124	8	2

Table 298: Highway Bridge Damage

Counties	# of Bridge	None (%)	Slight (%)	Moderate (%)	Extensive (%)	Complete (%)
Benton	52	90.39%	5.23%	0.30%	0.19%	3.87%
Carroll	122	73.88%	5.76%	3.74%	4.70%	11.89%
Cheatham	38	96.77%	1.97%	0.78%	0.41%	0.06%
Chester	41	69.63%	7.37%	5.16%	6.75%	11.07%
Crockett	56	37.99%	10.99%	8.89%	13.26%	28.85%
Davidson	521	98.52%	0.82%	0.37%	0.23%	0.03%
Decatur	39	87.00%	6.26%	2.15%	2.31%	2.25%
Dickson	68	97.41%	1.45%	0.69%	0.37%	0.05%
Dyer	121	11.92%	8.81%	7.76%	15.10%	56.39%
Fayette	129	66.43%	5.31%	4.79%	7.81%	15.65%
Gibson	141	46.26%	9.07%	7.84%	11.62%	25.19%
Giles	117	98.01%	1.26%	0.45%	0.23%	0.03%
Hardeman	90	65.65%	7.59%	5.33%	7.13%	14.28%
Hardin	58	82.72%	10.12%	0.67%	0.39%	6.08%
Haywood	133	40.32%	10.85%	8.24%	12.89%	27.68%
Henderson	89	76.47%	7.33%	4.51%	5.76%	5.90%
Henry	86	74.02%	8.36%	4.06%	5.17%	8.35%
Hickman	71	98.55%	0.93%	0.31%	0.17%	0.02%
Houston	22	96.33%	2.37%	0.82%	0.41%	0.06%
Humphreys	66	96.42%	2.77%	0.50%	0.26%	0.03%
Lake	14	48.79%	8.68%	5.30%	6.68%	30.52%
Lauderdale	94	12.95%	8.94%	8.23%	16.49%	53.36%
Lawrence	43	97.96%	1.26%	0.48%	0.25%	0.03%
Lewis	21	97.49%	1.65%	0.54%	0.27%	0.03%
Madison	145	62.58%	9.18%	6.15%	7.99%	14.08%
Maury	147	98.40%	1.00%	0.36%	0.20%	0.03%
McNairy	90	80.69%	7.33%	2.80%	3.24%	5.92%
Montgomery	80	98.38%	1.06%	0.34%	0.18%	0.02%
Obion	144	40.99%	9.80%	7.13%	12.34%	29.71%
Perry	36	91.69%	6.83%	0.45%	0.97%	0.05%
Robertson	79	98.77%	0.82%	0.24%	0.13%	0.02%
Shelby	436	28.61%	8.86%	7.74%	16.26%	38.50%
Stewart	70	94.51%	2.61%	1.06%	1.02%	0.77%
Tipton	54	23.71%	7.95%	8.91%	17.31%	42.10%
Wayne	44	97.70%	1.57%	0.45%	0.23%	0.03%
Weakley	131	60.46%	6.77%	5.63%	8.00%	19.11%
Williamson	127	96.84%	1.94%	0.76%	0.40%	0.05%

Table 299: Highway Bridge Functionality

Counties	# of Bridges	At day 1 (%)	At day 3 (%)	At day 7 (%)	At day 30 (%)	At day 90 (%)
Benton	52	94.43	95.82	95.94	96.02	96.38
Carroll	122	79.63	82.18	83.66	84.42	87.54
Cheatham	38	98.43	99.16	99.46	99.51	99.72
Chester	41	77.06	80.43	82.45	83.45	87.55
Crockett	56	49.78	55.16	58.72	60.71	69.23
Davidson	521	99.21	99.51	99.65	99.69	99.80
Decatur	39	92.38	94.58	95.43	95.76	97.05
Dickson	68	98.66	99.21	99.48	99.55	99.73
Dyer	121	22.35	26.89	30.08	32.53	43.83
Fayette	129	72.33	75.08	76.99	78.13	83.05
Gibson	141	56.18	60.77	63.89	65.64	73.11
Giles	117	99.03	99.47	99.65	99.69	99.80
Hardeman	90	73.36	76.83	78.94	80.03	84.52
Hardin	58	90.57	93.31	93.57	93.72	94.32
Haywood	133	51.79	56.93	60.23	62.14	70.42
Henderson	89	83.54	86.71	88.50	89.30	92.54
Henry	86	81.76	85.05	86.66	87.43	90.55
Hickman	71	99.30	99.61	99.73	99.75	99.83
Houston	22	98.30	99.13	99.45	99.51	99.72
Humphreys	66	98.60	99.43	99.63	99.66	99.79
Lake	14	57.61	61.30	63.46	64.74	70.11
Lauderdale	94	23.61	28.33	31.69	34.27	46.05
Lawrence	43	98.99	99.44	99.63	99.67	99.79
Lewis	21	98.83	99.40	99.61	99.65	99.78
Madison	145	71.75	75.86	78.29	79.49	84.39
Maury	147	99.21	99.55	99.69	99.72	99.82
McNairy	90	87.16	89.83	90.94	91.44	93.44
Montgomery	80	99.23	99.59	99.72	99.74	99.82
Obion	144	51.37	55.94	58.82	60.65	68.79
Perry	36	96.94	98.76	98.94	99.04	99.52
Robertson	79	99.42	99.68	99.77	99.79	99.85
Shelby	436	38.78	43.31	46.47	48.80	59.48
Stewart	70	96.77	97.73	98.15	98.29	98.85
Tipton	54	33.65	38.28	41.91	44.44	55.87
Wayne	44	98.96	99.48	99.65	99.68	99.80
Weakley	131	67.78	71.13	73.37	74.63	79.87
Williamson	127	98.47	99.17	99.46	99.52	99.72

Appendix VI: Social Impacts and Economic Losses

The results presented in this appendix are a more comprehensive representation of the information presented in the main section of this report. Each state is discussed individually and results are not summed over all States since different scenarios are employed for each. Only social impacts, induced damage and economic losses are explained herein. All damage to infrastructure is dealt with in another appendix. Social impacts and economic losses are shown for both critical counties and statewide totals. Social impacts include displaced population and short-term shelter estimates as well as feeding and space requirements for the temporary shelter population. Economic losses are shown for buildings, transportation lifelines and utility lifelines. The only form of induced damage included here is debris generation. Maps of social impacts and economic losses are not illustrated here, though are presented in another appendix. Numerous tables are provided, however, to illustrate social impacts and economic losses in each State. Additionally, social impacts and economic loss results both scenarios in Alabama and Indiana are presented herein.

Alabama – New Madrid Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate 112 thousand tons of debris, which will require 4,480 truckloads, each with 25-ton capacity, to remove. Of the debris, 78% (87 thousand tons) will be bricks, wood, and building contents, with steel and concrete comprising the balance (25 thousand tons).

There are roughly 4.4 million people that reside in the State of Alabama. A M_W7.7 event in the NMSZ displaces 27 people with the majority of those people living in the 12 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Alabama it is estimated that 5 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 2,400 square feet will be required, with 300 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 5 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 35 gallons of water, 380 pounds of ice, and 70 MRE's (meals ready to eat) in total. Quantities are displayed for the 12 critical counties for feeding, ice, and sleeping space requirements.

Table 1: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
12 Critical Counties	624, 368	24	5
Remaining Counties	3,822,732	3	0
Total State	4,447,100	27	5

Table 2: Worst Case Casualties - Event Occurs at 5:00 PM

Worst Case Casualties (5:00 PM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
12 Critical Counties	29	3	1	0	32
Other Remaining Counties	39	6	8	2	56
Total State	68	9	9	2	88

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The NMSZ event in Alabama results in the greatest number of casualties if the event occurs at 5:00 PM. A total of 88 casualties are expected from this event. There are two estimated fatalities and those occur outside the critical counties, though it is very unlikely that these fatalities occur. The value estimated is likely due to the addition of very small casualty likelihoods over a large area. Roughly 70 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

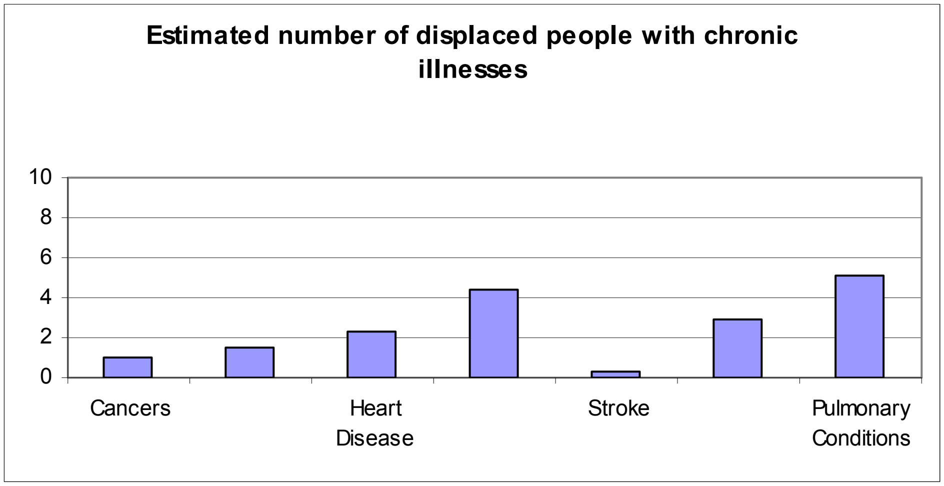

Figure 1: Estimated Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (27 people) and the prevalence of chronic conditions within Alabama (Milken Institute, 2007), it is estimated that there will be approximately 17 chronic cases that need to be cared for within the displaced population. It is possible that a person may suffer from more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 2 illustrates the building loss ratios for the entire State of Alabama. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratios are estimated at 5%, and appear to occur randomly throughout the state. This is due to the constant and low level of shaking throughout nearly the entire state. Though any damage that occurs will be minor, there is still a replacement cost associated with the damage. In counties where the value of buildings is not high, the ratio of the cost associated with minor repairs to buildings will be greater than in areas where the value of the built environment is greater. Non-structural damage, including damage to finishes, drywall, and flooring surfaces, total over $210 million, or over 50% of total building losses. Structural losses only contribute to 10% of all building losses. The remaining building losses are attributed to non-structural and business interruption losses.

Total direct economic losses for the state reach nearly $1.1 billion for the NMSZ M_w7.7 event. The majority of losses are attributed to utility losses; $569 million, or nearly 55% of total direct losses (see Table 6). The large amount of loss to the utility systems is due to slight damage to a

very large inventory of utility components. Transportation and building losses contribute far less, with roughly 9% and 38% of the total losses, respectively.

Table 3: Direct Building Losses ($ millions)

Direct Building Losses ($ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.00	0.35	10.45	0.45	0.67	11.92
Capital-Related	0.00	0.16	7.47	0.28	0.16	8.06
Rental	0.76	2.23	8.05	0.12	0.08	11.23
Relocation	0.07	0.12	0.42	0.01	0.04	0.66
Subtotal	0.83	2.86	26.39	0.86	0.95	31.88
Capital Stock Loses						
Structural	6.70	12.39	17.68	1.83	1.17	39.77
Non-Structural	73.10	43.25	80.14	10.14	6.33	212.96
Content	40.39	11.49	50.23	6.87	4.09	113.07
Inventory	0.00	0.00	4.27	1.91	0.06	6.25
Subtotal	120.19	67.14	152.32	20.75	11.65	372.05
Total	121.01	70.00	178.71	21.61	12.60	**403.93**

Table 4: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	80,718.01	0.00	0.00
	Bridges	11,932.03	22.50	0.19
	Tunnels	0.00	0.00	0.00
Railways	Segments	4,228.50	0.00	0.00
	Bridges	10.27	0.00	0.00
	Facilities	213.86	3.52	1.65
Bus	Facilities	23.54	0.58	2.48
Light Rail	Segments	0.00	0.00	0.00
	Facilities	0.00	0.00	0.00
Ferry	Facilities	6.74	6.74	100.00
Port	Facilities	629.80	11.80	1.87
Airport	Facilities	2,300.45	50.51	2.20
	Runways	8,167.82	0.00	0.00
Total		**108,231.00**	**95.70**	

Table 5: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	899.10	5.43	0.60
	Distribution Lines	4,017.90	3.25	0.08
Waste Water	Facilities	24,575.40	116.18	0.47
	Distribution Lines	2,410.75	2.57	0.11
Natural Gas	Facilities	361.00	1.87	0.52
	Local Pipelines	1,607.10	2.75	0.17
	Regional Pipelines	4,926.40	0.02	0.00
Oil Systems	Facilities	10.10	0.04	0.00
	Regional Pipelines	1,645.40	0.00	0.00
Electrical Power	Facilities	141,075.00	430.50	0.31
Communication	Facilities	1,380.70	6.18	0.45
Total		**182,908.80**	**568.77**	

Table 6: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$269,580,000,000	$403,930,000
Transportation	$108,231,000,000	$95,700,000
Utility	$182,908,800,000	$568,770,000
Total	**$559,819,800,000**	**$1,068,400,000**

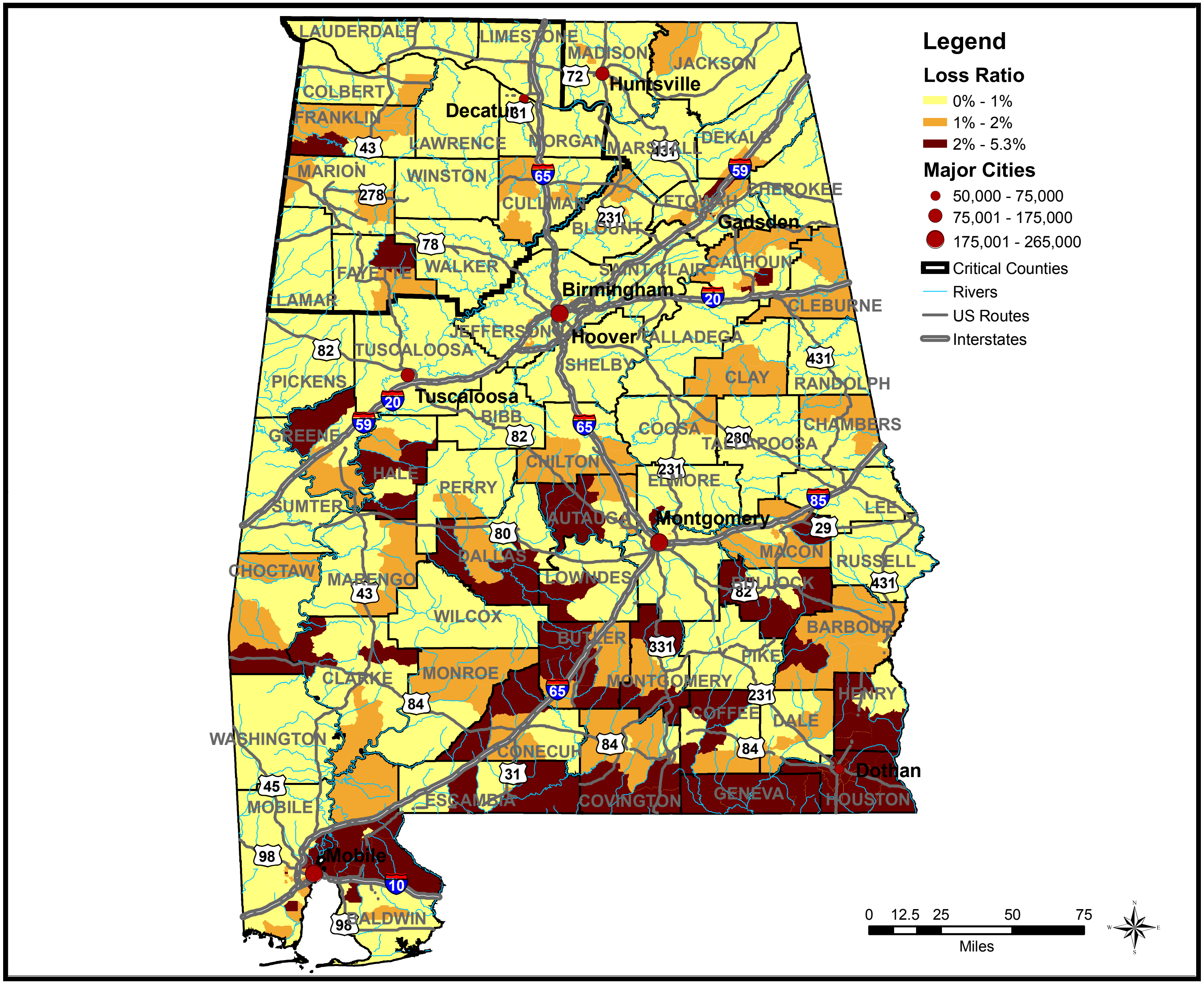

Figure 2: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 12 critical counties is illustrated in the following tables.

Table 7: Time-of-Day Casualties, 5:00 PM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Colbert	5	0	0	0	5
Cullman	1	0	0	0	1
Fayette	2	0	0	0	2
Franklin	2	0	0	0	2
Lamar	2	0	0	0	2
Lauderdale	9	1	0	0	10
Lawrence	0	0	0	0	0
Limestone	1	0	0	0	1
Marion	3	0	0	0	3
Morgan	1	0	0	0	1
Walker	1	0	0	0	1
Winston	2	0	0	0	2

Table 8: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Colbert	54,984	5	1
Cullman	77,483	0	0
Fayette	18,495	1	0
Franklin	31,223	1	0
Lamar	15,904	1	0
Lauderdale	87,966	13	4
Lawrence	34,803	0	0
Limestone	65,676	0	0
Marion	31,214	2	0
Morgan	111,064	0	0
Walker	70,713	0	0
Winston	24,843	1	0

Table 9: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Colbert	480	60	35	56	14
Cullman	0	0	0	0	0
Fayette	0	0	0	0	0
Franklin	0	0	0	0	0
Lamar	0	0	0	0	0
Lauderdale	1,920	240	140	224	56
Lawrence	0	0	0	0	0
Limestone	0	0	0	0	0
Marion	0	0	0	0	0
Morgan	0	0	0	0	0
Walker	0	0	0	0	0
Winston	0	0	0	0	0

Table 10: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Colbert	6.06	2.48	8.54
Cullman	0.85	0.16	1.01
Fayette	2.61	1.10	3.71
Franklin	1.72	0.58	2.30
Lamar	2.78	1.04	3.82
Lauderdale	10.36	4.16	14.52
Lawrence	0.34	0.05	0.40
Limestone	0.57	0.09	0.67
Marion	2.96	1.16	4.13
Morgan	1.14	0.22	1.36
Walker	0.83	0.15	0.98
Winston	2.51	1.00	3.51

Alabama – East Tennessee Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate 146 thousand tons of debris, which will require 5,840 truckloads, each with 25-ton capacity, to remove. Of the debris, 58% (85 thousand tons) will be bricks, wood, and building contents, with steel and concrete comprising the balance (61 thousand tons).

There are roughly 4.4 million people that reside in the State of Alabama. A M_w5.9 event in the ETSZ displaces 1,625 people all of whom reside in the 13 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Alabama it is estimated that 440 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 211,200 square feet will be required, with 26,400 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 440 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 15,400 gallons of water, 24,640 pounds of ice, and approximately 6,160 MRE's (meals ready to eat) in total. Quantities are displayed for the 13 critical counties for feeding, ice, and sleeping space requirements.

Table 11: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
13 Critical Counties	1,751,879	1,625	440
Remaining Counties	2,695,221	0	0
Total State	4,447,100	1,625	440

Table 12: Worst Case Casualties – Event Occurs at 2:00 AM

Worst Case Casualties (2:00 AM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
13 Critical Counties	153	32	3	4	192
Other Remaining Counties	1	0	0	0	1
Total for State of Alabama	154	32	3	4	193

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The ETSZ event in Alabama results in the greatest number of casualties if the event occurs at 2:00 AM. A total of 193 casualties are expected from this event. There are 4 estimated fatalities and those occur within the critical counties. It is very unlikely that fatalities occur outside the critical counties. The value estimated for casualties is likely due to the addition of very small casualty likelihoods over a large area. Roughly 154 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least sever and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

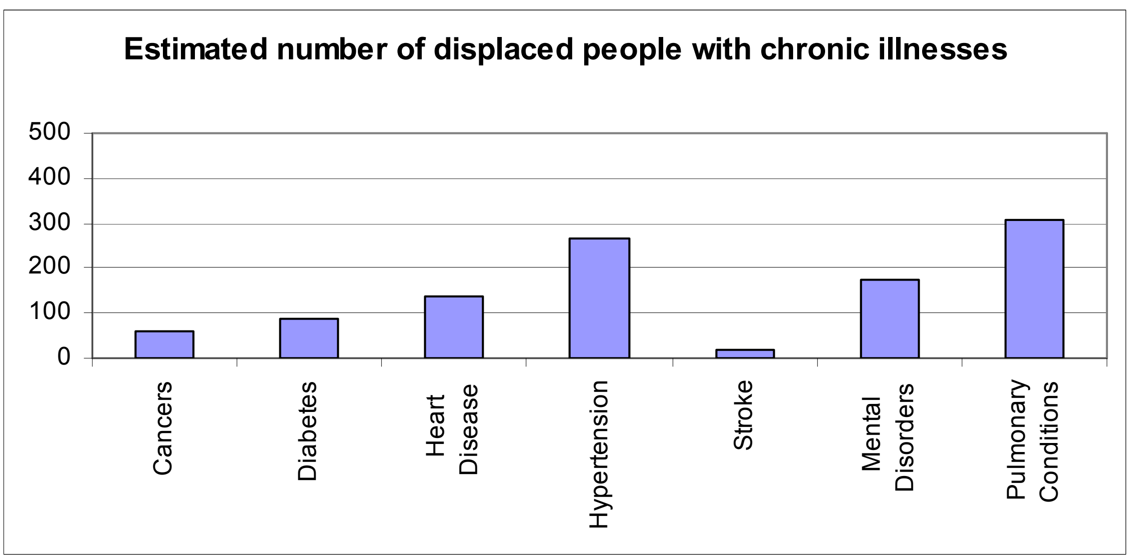

Figure 3: Estimated Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (1,625

people) and the prevalence of chronic conditions within Alabama (Milken Institute, 2007), it is estimated that there will be approximately 1,050 chronic cases that need to be cared for within the displaced population. It is possible that a person may suffer from more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 4 illustrates the building loss ratios for the entire State of Alabama. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratio is estimated at nearly 10% and occurs in the northeastern portion of the state. Though any damage that occurs will not be complete damage there is still a replacement cost associated with the damage. In counties where the value of buildings is not high the ratio of the cost associated with minor repairs to buildings will be greater than in areas where the value of the built environment is greater. Non-structural damage, including damage to finishes, drywall, and flooring surfaces, total over $216 million or over 50% of total building losses. Structural losses only contribute to 11% of all building losses. The remaining building losses are attributed to non-structural and business interruption losses.

Table 13: Direct Building Losses ($ millions)

Direct Building Losses ($ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.0	0.62	6.66	1.73	0.29	9.30
Capital-Related	0.0	0.27	5.02	1.05	0.08	6.42
Rental	4.85	3.90	4.18	0.57	0.10	13.60
Relocation	0.53	0.14	0.24	0.01	0.04	0.96
Subtotal	5.38	4.93	16.10	3.36	0.51	30.28
Capital Stock Loses						
Structural	22.14	8.79	9.24	4.77	0.92	45.86
Non-Structural	117.8	36.95	41.95	15.76	3.49	215.95
Content	49.74	9.69	31.12	11.97	2.34	104.86
Inventory	0.0	0.0	2.82	4.22	0.06	7.10
Subtotal	189.68	55.43	85.13	36.72	6.81	373.77
Total	195.06	60.36	101.23	40.08	7.32	**404.05**

Total direct economic losses for the state reach nearly $700 million from the ETSZ M5.9 event. The majority of losses are attributed to building losses, $404 million, or nearly

60% of total direct losses (see Table 16). Furthermore, utility losses contribute to 36% of the total losses while transportation contributes far less, with roughly 6% of the total losses.

Table 14: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments	80,718.01	0.09	0.00
	Bridges	11,932.03	2.86	0.02
	Tunnels	0.00	0.00	0.00
Railways	Segments	4,228.50	0.00	0.00
	Bridges	10.27	0.00	0.00
	Facilities	213.86	1.20	0.56
Bus	Facilities	23.54	0.12	0.52
Ferry	Facilities	6.74	6.74	100.00
Port	Facilities	629.80	2.31	0.37
Airport	Facilities	2,300.45	26.66	1.16
	Runways	8,167.82	0.00	0.00
Total		**108,231.02**	**39.98**	

Table 15: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	899.10	10.30	1.15
	Distribution Lines	4,017.90	1.09	0.03
Waste Water	Facilities	24,575.40	100.76	0.41
	Distribution Lines	2,410.70	0.86	0.04
Natural Gas	Facilities	361.00	0.23	0.06
	Local Pipelines	1,607.10	0.92	0.06
	Regional Pipelines	4,926.40	0.00	0.00
Oil Systems	Facilities	10.10	0.00	0.02
	Regional Pipelines	1,645.40	0.00	0.00
Electrical Power	Facilities	141,075.00	133.62	0.09
Communication	Facilities	1,380.70	6.62	0.48
Total		**182,908.80**	**254.40**	

Table 16: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$269,580,000,000	$404,030,000
Transportation	$108,231,020,000	$39,980,000
Utility	$182,908,800,000	$254,400,000
Total	**$560,719,820,000**	**$698,410,000**

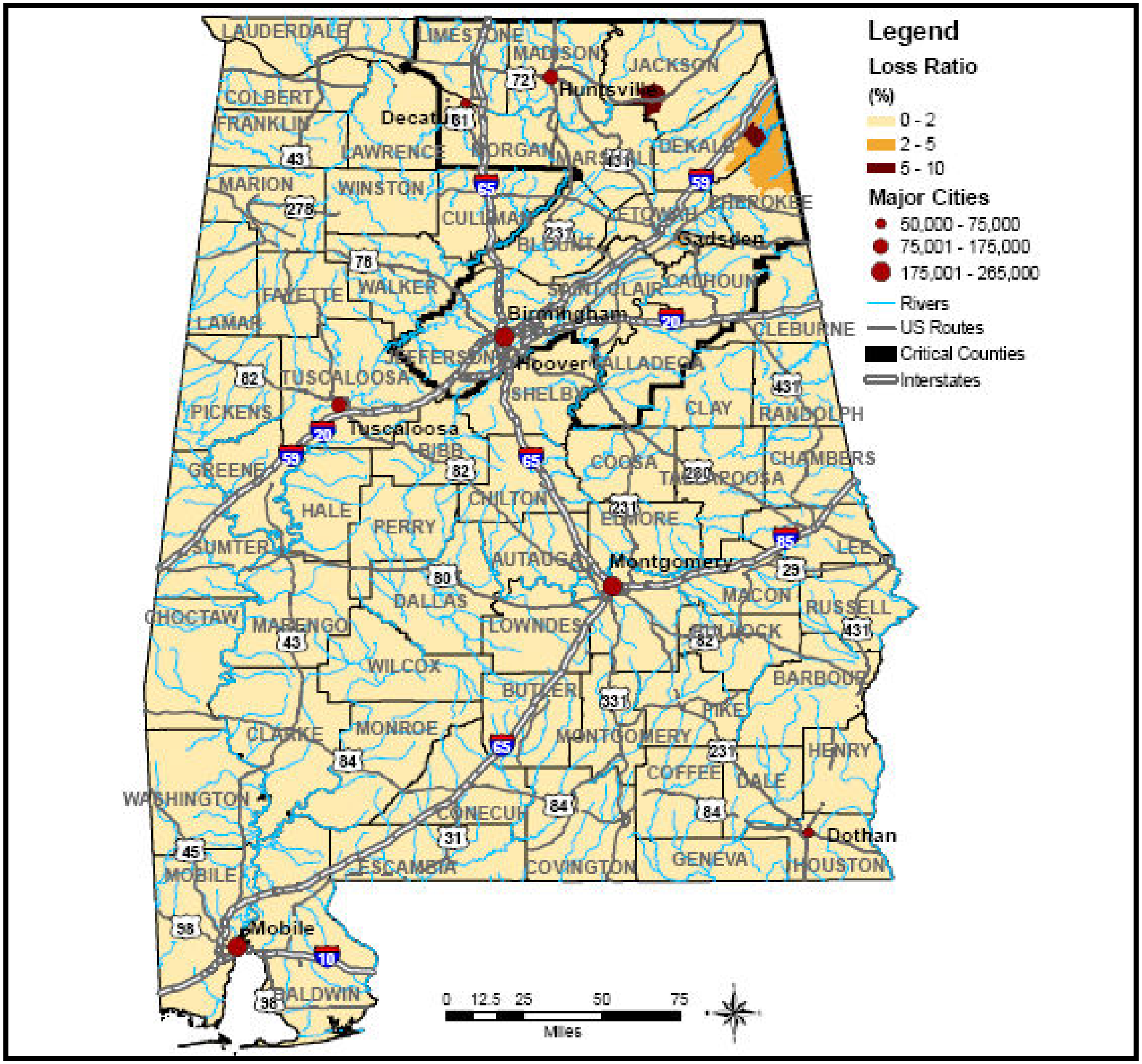

Figure 4: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 13 critical counties is illustrated in the following tables.

Table 17: Time-of-Day Casualties, 2:00 AM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Blount	0	0	0	0	0
Calhoun	1	0	0	0	1
Cherokee	9	1	0	0	10
Dekalb	54	8	1	1	64
Etowah	51	14	1	2	58
Jackson	36	9	1	1	47
Jefferson	0	0	0	0	0
Limestone	0	0	0	0	0
Madison	1	0	0	0	1
Marshall	1	0	0	0	1
Morgan	0	0	0	0	0
Saint Clair	0	0	0	0	0
Talladega	0	0	0	0	0

Table 18: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Blount	51,024	0	0
Calhoun	112,249	0	0
Cherokee	23,988	4	1
Dekalb	64,452	263	75
Etowah	103,459	803	225
Jackson	53,926	555	139
Jefferson	662,047	0	0
Limestone	65,676	0	0
Madison	276,700	0	0
Marshall	82,231	0	0
Morgan	111,064	0	0
Saint Clair	64,742	0	0
Talladega	80,321	0	0

Table 19: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Blount	0	0	0	0	0
Calhoun	0	0	0	0	0
Cherokee	480	60	35	56	14
Dekalb	36,000	4,500	2,625	4,200	1,050
Etowah	108,000	13,500	7,875	12,600	3,150
Jackson	66,720	8,340	4,865	7,784	1,946
Jefferson	0	0	0	0	0
Limestone	0	0	0	0	0
Madison	0	0	0	0	0
Marshall	0	0	0	0	0
Morgan	0	0	0	0	0
Saint Clair	0	0	0	0	0
Talladega	0	0	0	0	0

Table 20: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Blount	7.74	0.92	8.66
Calhoun	0.77	0.07	0.84
Cherokee	6.82	2.23	9.05
Dekalb	40.74	36.04	76.78
Etowah	13.37	12.21	25.58
Jackson	10.66	9.23	19.89
Jefferson	0.83	0.04	0.87
Limestone	0.12	0.01	0.12
Madison	1.42	0.10	1.52
Marshall	1.23	0.17	1.39
Morgan	0.32	0.02	0.34
Saint Clair	0.30	0.03	0.32
Talladega	0.16	0.01	0.17

Arkansas – New Madrid Seismic Zone

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate approximately 7 million tons of debris, which will require 280,000 truckloads, each with 25-ton capacity. Of the debris, 48% (3.4 million tons) will be brick, wood, and building contents, with steel and concrete comprising the balance (3.6 million tons).

There are roughly 2.7 million people that reside in the State of Arkansas. A M_w7.7 event in the NMSZ displaces 127,000 people with the majority of those people living in the 34 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Arkansas it is estimated that 37,250 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 17,877,000 square feet of shelter space will be required, with 2,234,600 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 37,250 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 1,303,540 gallons of water, 2,085,700 pounds of ice, and 24 truckloads of 521,400 MRE's (meals ready to eat) in total. Quantities are displayed for the 34 critical counties for feeding, ice, and sleeping space requirements.

Table 21: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
34 Critical Counties	1,330,090	126,987	37,244
Remaining Counties	1,334,739	1	0
Total State	2,664,829	126,988	37,244

Table 22: Worst Case Casualties - Event Occurs at 2:00 AM

Worst Case Casualties (2:00 AM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
34 Critical Counties	10,275	2,796	306	574	13,951
Remaining Counties	21	1	4	0	26
State Total	**10,296**	**2,797**	**310**	**574**	**13,977**

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The NMSZ event in Arkansas results in the greatest number of casualties if the event occurs at 2:00 AM. A total of 13,977 casualties are expected from this event. There are 574 estimated fatalities of which most occur inside the critical counties. Roughly 10,300 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake

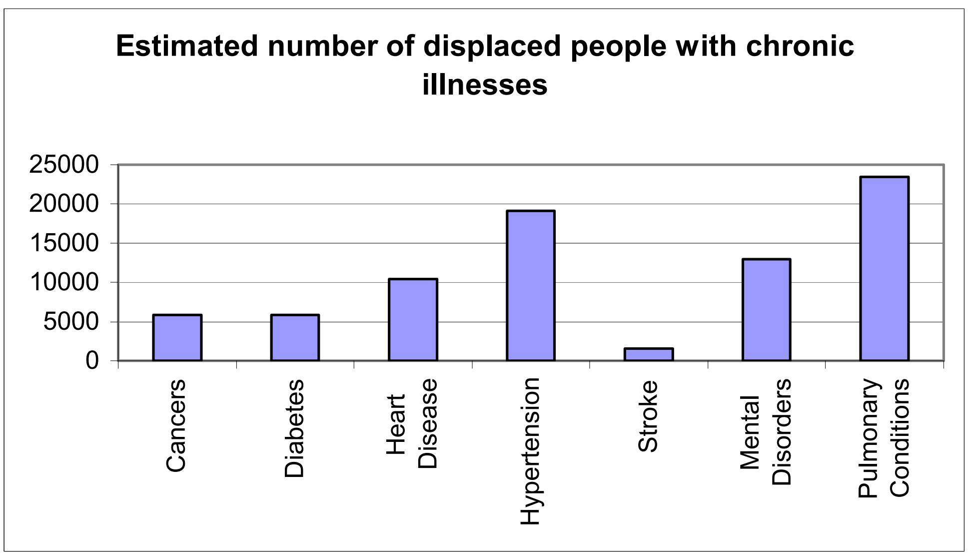

Figure 5: Estimates Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (126,988 people) and the prevalence of chronic conditions within Arkansas (Milken Institute, 2007), it is estimated that there will be approximately 79,241 chronic cases that need to

be cared for within the displaced population. It is possible that a person may suffer from more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 6 illustrates the building loss ratios for the entire state. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratios are estimated at 75% or more, and occur in the northeastern counties where shaking is most intense. Some eastern counties show loss ratios between 25% and 50% where shaking is moderate. These loss ratios should be considered a concern since 25% to 50% of the total building value in a given census tract is lost. It is more common to see ratios between 0% and 10% in the remainder of the state which is not as critical although still warrants consideration. Also of particular interest is the level of non-structural damage which totals nearly $7.0 billion or over 55% of total building losses. Structural losses only contribute 15% of all building loses. The remaining building losses are attributed to non-structural and business interruption losses.

Total direct economic losses for the state reach nearly $18.9 billion from the NMSZ M_w7.7 event. The majority of losses are attributed to building losses, $12.6 billion, or nearly two-thirds of total direct losses (see Table 26). Transportation and utility losses contribute far less, with roughly 11% and 22% of the total losses, respectively.

Table 23: Direct Building Losses ($ millions)

Direct Building Losses ($ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.00	24.71	324.48	17.88	15.74	382.81
Capital-Related	0.00	10.93	249.94	10.87	5.23	276.97
Rental	263.72	169.05	126.88	6.93	6.3	572.88
Relocation	29.18	4.67	8.63	0.52	2.16	45.16
Subtotal	292.9	209.36	709.93	36.2	29.43	1,277.82
Capital Stock Loses						
Structural	1,193.05	302.12	355.73	82.57	77.41	2,010.88
Non-Structural	4,135.98	1,270.27	1,046.41	349.41	183.68	6,985.75
Content	1,105.22	283.69	510.33	229.04	96.34	2,224.62
Inventory	0.00	0.00	27.58	64.75	5.83	98.16
Subtotal	6,434.25	1,856.08	1,940.05	725.77	363.26	11,319.41
Total	6,727.15	2,065.44	2,649.98	761.97	392.69	12,597.23

Table 24: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments	49,994.91	1,266.31	2.53
	Bridges	6,308.93	364.63	5.78
	Tunnels	9.60	0.00	0.00
Railways	Segments	3,365.10	87.12	2.59
	Bridges	4.67	0.35	7.40
	Facilities	128.97	25.07	19.44
Bus	Facilities	15.17	1.42	9.33
Light Rail	Segments	0.00	0.00	0.00
	Facilities	0.00	0.00	0.00
Ferry	Facilities	0.95	0.95	100.00
Port	Facilities	187.76	37.22	19.82
Airport	Facilities	1,488.83	185.08	12.43
	Runways	6,435.42	186.51	2.90
Total		**67,940.31**	**2,154.66**	

Table 25: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	1,999.00	90.05	4.50
	Distribution Lines	3,821.70	336.99	8.82
Waste Water	Facilities	23,814.20	2,650.81	11.13
	Distribution Lines	2,293.00	266.52	11.62
Natural Gas	Facilities	92.00	2.49	2.70
	Local Pipelines	1528.70	284.91	18.64
	Regional Pipelines	7,308.30	13.96	0.19
Oil Systems	Facilities	0.90	0.09	10.31
	Regional Pipelines	1387.50	3.63	0.26
Electrical Power	Facilities	5,359.20	474.00	8.84
Communication	Facilities	54.40	3.28	6.03
Total		**47,658.90**	**4,126.73**	

Table 26: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$157,602,000,000	$12,597,230,000
Transportation	$67,940,310,000	$2,154,660,000
Utility	$47,658,900,000	$4,126,730,000
Total	**$273,201,210,000**	**$18,878,620,000**

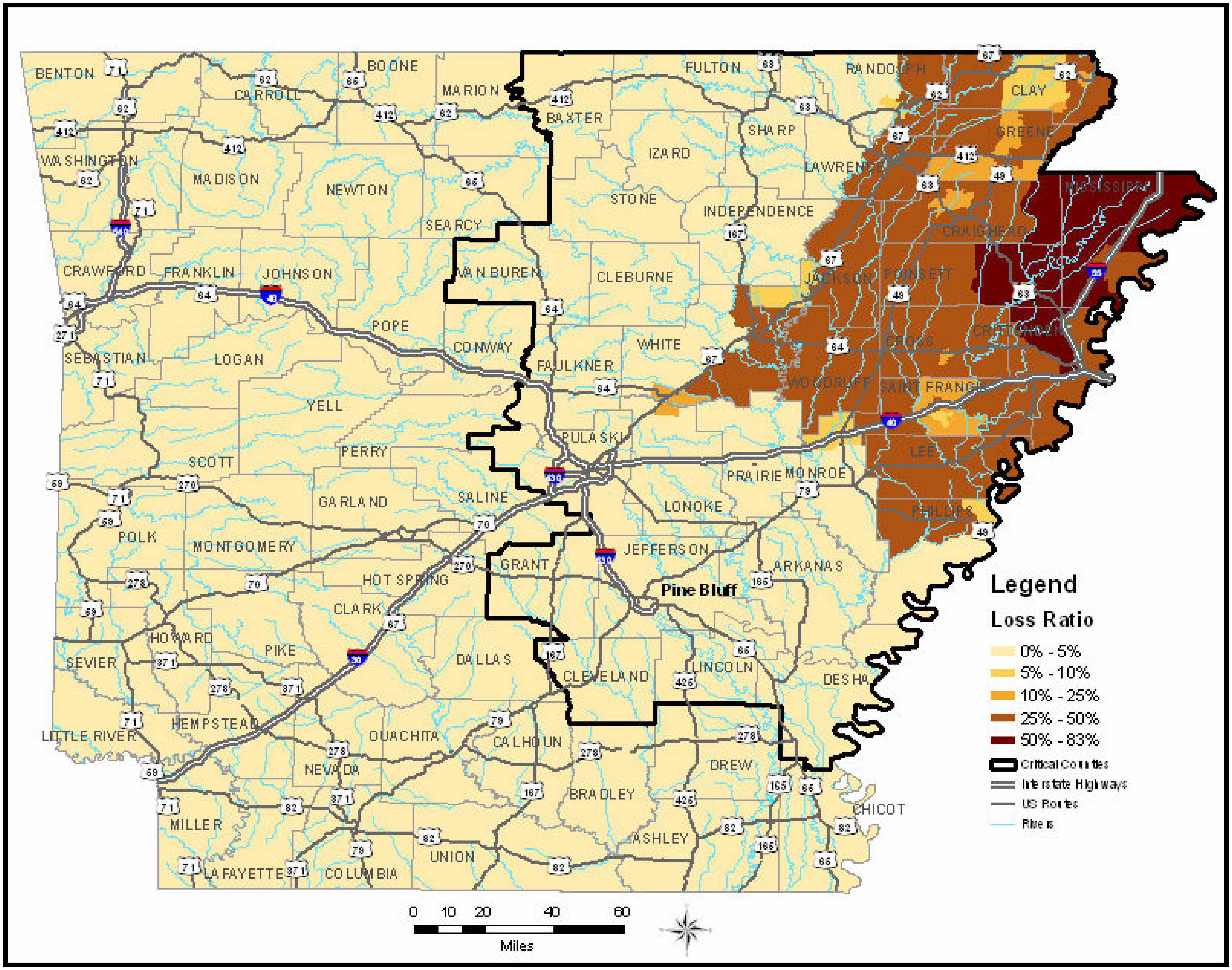

Figure 6: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 34 critical counties is illustrated in the following tables.

Table 27: Time-of-Day Casualties, 2:00 AM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Arkansas	21	4	0	0	25
Baxter	1	0	0	0	1
Clay	260	69	7	13	349
Cleburne	2	0	0	0	2
Cleveland	2	0	0	0	2
Craighead	1,884	526	64	122	2,596
Crittenden	1,311	364	40	74	1,789
Cross	448	121	12	22	603
Desha	3	0	0	0	3
Faulkner	1	0	0	0	1
Fulton	0	0	0	0	0
Grant	2	0	0	0	2
Greene	588	155	18	33	794
Independence	7	1	0	0	8
Izard	0	0	0	0	0
Jackson	343	92	9	17	461
Jefferson	17	1	0	0	18
Lawrence	226	61	6	12	305
Lee	255	69	7	13	344
Lincoln	4	0	0	0	4
Lonoke	49	11	1	2	63
Mississippi	2,414	673	76	141	3,304
Monroe	26	5	0	1	32
Phillips	325	88	8	15	436
Poinsett	970	273	31	59	1,333
Prairie	14	2	0	0	16
Pulaski	52	4	0	0	56
Randolph	105	27	3	5	140
St. Francis	353	91	9	17	470
Sharp	2	0	0	0	2
Stone	0	0	0	0	0
Van Buren	0	0	0	0	0
White	419	113	11	20	563
Woodruff	171	46	4	8	229

Table 28: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Arkansas	20,749	182	52
Baxter	38,386	0	0
Clay	17,609	3,051	891
Cleburne	24,046	0	0
Cleveland	8,571	0	0
Craighead	82,148	20,510	5,345
Crittenden	50,866	17,210	5,180
Cross	19,526	6,204	1,810
Desha	15,341	1	0
Faulkner	86,014	0	0
Fulton	11,642	0	0
Grant	16,464	0	0
Greene	37,331	6,651	1,776
Independence	34,233	1	0
Izard	13,249	0	0
Jackson	18,418	4,413	1,331
Jefferson	84,278	6	2
Lawrence	17,774	2,907	825
Lee	12,580	3,356	1,154
Lincoln	14,492	0	0
Lonoke	52,828	522	129
Mississippi	51,979	30,911	9,365
Monroe	10,254	198	67
Phillips	26,445	4,574	1,527
Poinsett	25,614	12,249	3,555
Prairie	9,539	139	40
Pulaski	361,474	55	15
Randolph	18,195	1,305	374
St. Francis	29,329	4,484	1,419
Sharp	17,119	0	0
Stone	11,499	0	0
Van Buren	16,192	0	0
White	67,165	5,745	1,621
Woodruff	8,741	2,313	766

Table 29: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Arkansas	24,960	3,120	1,820	2,912	728
Baxter	0	0	0	0	0
Clay	427,680	53,460	31,185	49,896	12,474
Cleburne	0	0	0	0	0
Cleveland	0	0	0	0	0
Craighead	2,565,600	320,700	187,075	299,320	74,830
Crittenden	2,486,400	310,800	181,300	290,080	72,520
Cross	868,800	108,600	63,350	101,360	25,340
Desha	0	0	0	0	0
Faulkner	0	0	0	0	0
Fulton	0	0	0	0	0
Grant	0	0	0	0	0
Greene	852,480	106,560	62,160	99,456	24,864
Independence	0	0	0	0	0
Izard	0	0	0	0	0
Jackson	638,880	79,860	46,585	74,536	18,634
Jefferson	960	120	70	112	28
Lawrence	396,000	49,500	28,875	46,200	11,550
Lee	553,920	69,240	40,390	64,624	16,156
Lincoln	0	0	0	0	0
Lonoke	61,920	7,740	4,515	7,224	1,806
Mississippi	4,495,200	561,900	327,775	524,440	131,110
Monroe	32,160	4,020	2,345	3,752	938
Phillips	732,960	91,620	53,445	85,512	21,378
Poinsett	1,706,400	213,300	124,425	199,080	49,770
Prairie	19,200	2,400	1,400	2,240	560
Pulaski	7,200	900	525	840	210
Randolph	179,520	22,440	13,090	20,944	5,236
St. Francis	681,120	85,140	49,665	79,464	19,866
Sharp	0	0	0	0	0
Stone	0	0	0	0	0
Van Buren	0	0	0	0	0
White	778,080	97,260	56,735	90,776	22,694
Woodruff	367,680	45,960	26,810	42,896	10,724

Table 30: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Arkansas	15.93	27.10	43.03
Baxter	0.77	0.11	0.87
Clay	97.15	91.99	189.14
Cleburne	1.57	0.37	1.94
Cleveland	1.85	0.42	2.27
Craighead	664.68	884.90	1,549.58
Crittenden	365.53	419.89	785.42
Cross	135.00	149.01	284.01
Desha	3.38	1.46	4.83
Faulkner	1.45	0.23	1.68
Fulton	0.22	0.03	0.25
Grant	1.11	0.24	1.34
Greene	214.87	220.95	435.83
Independence	9.06	3.29	12.35
Izard	0.24	0.03	0.27
Jackson	109.22	114.11	223.33
Jefferson	20.57	7.24	27.80
Lawrence	72.07	73.44	145.51
Lee	62.82	60.25	123.07
Lincoln	2.96	1.06	4.01
Lonoke	23.68	20.64	44.33
Mississippi	700.41	715.07	1,415.48
Monroe	17.98	19.59	37.57
Phillips	87.02	92.42	179.44
Poinsett	315.27	411.49	726.76
Prairie	9.61	12.84	22.45
Pulaski	89.54	38.70	128.24
Randolph	40.66	41.17	81.83
St. Francis	118.23	126.44	244.67
Sharp	3.93	1.28	5.21
Stone	0.23	0.03	0.26
Van Buren	0.33	0.04	0.37
White	119.86	121.16	241.03
Woodruff	53.61	51.04	104.65

Illinois – New Madrid Seismic Zone

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate 2.57 million tons of debris, which will require 102,800 truckloads, each with 25-ton capacity. Of the debris, 54 percent (1.4 million tons) will be bricks, wood, and building contents, with the balance (1.17 million tons) comprising steel and concrete.

There are roughly 12.4 million people that reside in the State of Illinois. A M_w7.7 event in the NMSZ displaces 51,500 people with the majority of those people living in the 40 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Illinois it is estimated that roughly 14,700 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 7,063,680 square feet will be required, with 882,960 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for over 14,700 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 161,900 gallons of water, 1,295,000 pounds of ice, and fifteen truckloads of 323,750 MRE's (meals ready to eat) in total. Quantities are displayed for the 40 critical counties for feeding, ice, and sleeping space requirements.

Table 31: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
40 Critical Counties	1,347,307	51,426	14,716
Remaining Counties	11,071,996	43	10
Total State	12,419,293	51,469	14,726

Table 32: Worst Case Casualties – Event Occurs at 2:00 AM

Worst Case Casualties (2:00 AM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
40 Critical Counties	4,478	1,236	146	276	6,136
Other Remaining Counties	109	5	0	0	114
Total for State of Illinois	4,587	1,241	146	276	6,250

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The NMSZ event in Illinois results in the greatest number of casualties if the event occurs at 2:00 AM. A total of 6,250 casualties are expected from this event. There are 276 estimated fatalities and those occur within the critical counties. Roughly 4,600 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

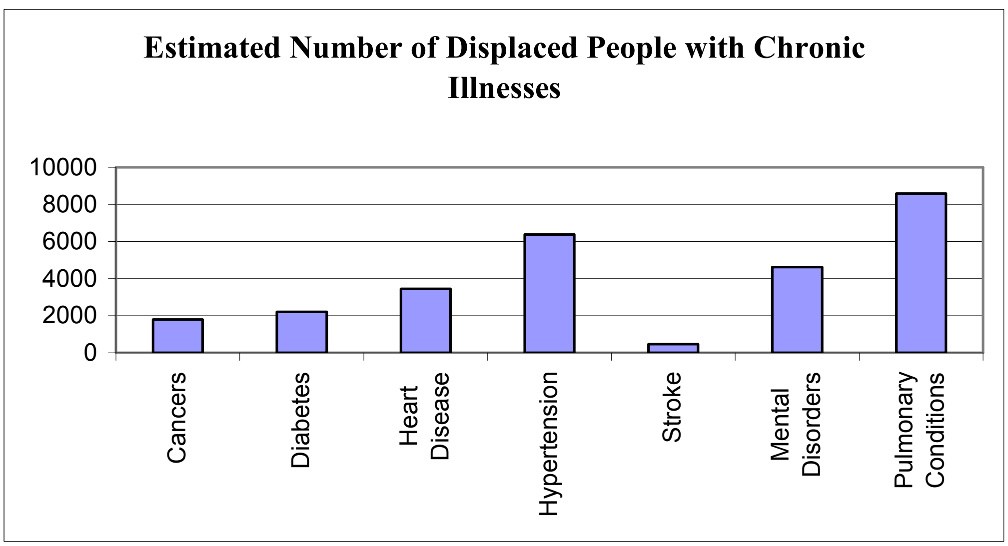

Figure 7: Displaced People with Chronic Illness

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in vulnerability of the population post-event. By combining estimates of the displaced population (51,500 people) and the prevalence of chronic conditions within Illinois (Milken Institute, 2007), it is estimated that there will be approximately 27,499 chronic cases that need to be cared

for within the displaced population. It is possible that a person may suffer from more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 8 illustrates the building loss ratios for the entire state. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratios are estimated at 81%, and occur in the southwestern most counties where shaking is most intense. Some areas along the Mississippi River show loss ratios between 25% and 40% where shaking is moderate. These loss ratios should be considered a concern since 25% to 40% of the total building value in a given census tract is lost. Ratios between 0% and 10% are expected in the remainder of the state. Non-structural damage, including damage to finishes, drywall, and flooring surfaces, total nearly \$3.1 billion or over 56% of total building losses. Structural losses only contribute to 14% of all building losses. The remaining building losses are attributed to non-structural and business interruption losses.

Total direct economic losses for the state reach \$34.1 billion from the NMSZ M_w7.7 event. The majority of losses are attributed to utility losses, \$26.8 billion, or nearly three-fourths of total direct losses. Transportation and building losses contribute far less, with roughly 5% and 16% of the total losses, respectively.

Table 33: Direct Building Losses (\$ millions)

Direct Building Losses ($ millions)						
	Single Family	**Other Residential**	**Commercial**	**Industrial**	**Others**	**Total**
Business Interruption Loses						
Wage	0.00	10.70	96.28	2.46	8.26	117.70
Capital-Related	0.00	4.86	76.42	1.57	2.40	85.25
Rental	91.92	61.26	36.49	0.66	3.46	193.79
Relocation	10.11	1.73	2.35	0.09	1.11	15.39
Subtotal	102.04	78.54	211.54	4.77	15.23	412.13
Capital Stock Loses						
Structural	471.83	152.16	112.95	16.15	33.74	786.83
Non-Structural	1,735.84	735.71	422.62	85.06	121.35	3,100.57
Content	556.99	197.94	246.40	57.69	70.15	1,129.17
Inventory	0.00	0.00	9.35	11.72	1.46	22.53
Subtotal	2,764.66	1,085.81	791.32	170.61	226.69	5,039.09
Total	2,866.70	1,164.35	1,002.86	175.38	241.93	**5,451.22**

Table 34: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	95,066.33	233.74	0.25
	Bridges	21,107.01	276.59	1.31
	Tunnels	0.00	0.00	0.00
Railways	Segments	11,844.99	34.31	0.29
	Bridges	110.98	0.81	1.31
	Facilities	689.64	30.28	4.39
Bus	Facilities	143.98	5.70	3.96
Light Rail	Segments	124.88	0.01	0.01
	Facilities	900.41	900.41	100.00
Ferry	Facilities	13.31	13.31	100.00
Port	Facilities	1,154.14	69.54	6.03
Airport	Facilities	5,619.99	277.47	4.94
	Runways	24,321.65	41.01	0.17
Total		**161,097.31**	**1,883.18**	

Table 35: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Facilities	8,945.00	315.31	3.52
	Distribution Lines	5,308.00	64.99	1.22
Waste Water	Facilities	694,091.20	20,681.05	2.98
	Distribution Lines	3,184.80	51.40	1.61
Natural Gas	Facilities	1,612.80	57.78	3.58
	Local Pipelines	2,123.20	54.94	2.59
	Regional Pipelines	11,623.00	0.10	0.00
Oil Systems	Facilities	30.50	0.57	1.87
	Regional Pipelines	5,689.70	0.08	0.00
Electrical Power	Facilities	265,201.20	5,447.65	2.05
Communication	Facilities	3,866.50	105.37	2.73
Total		**1,001,675.90**	**26,779.24**	

Table 36: Total Direct Economic Losses

Total Direct Economic Losses		
System	Inventory Value	Total Direct Economic Loss
Buildings	$837,682,000,000	$5,451,220,000
Transportation	$161,097,310,000	$1,883,180,000
Utility	$1,001,675,900,000	$26,779,240,000
Total	**$2,000,455,210,000**	**$34,113,640,000**

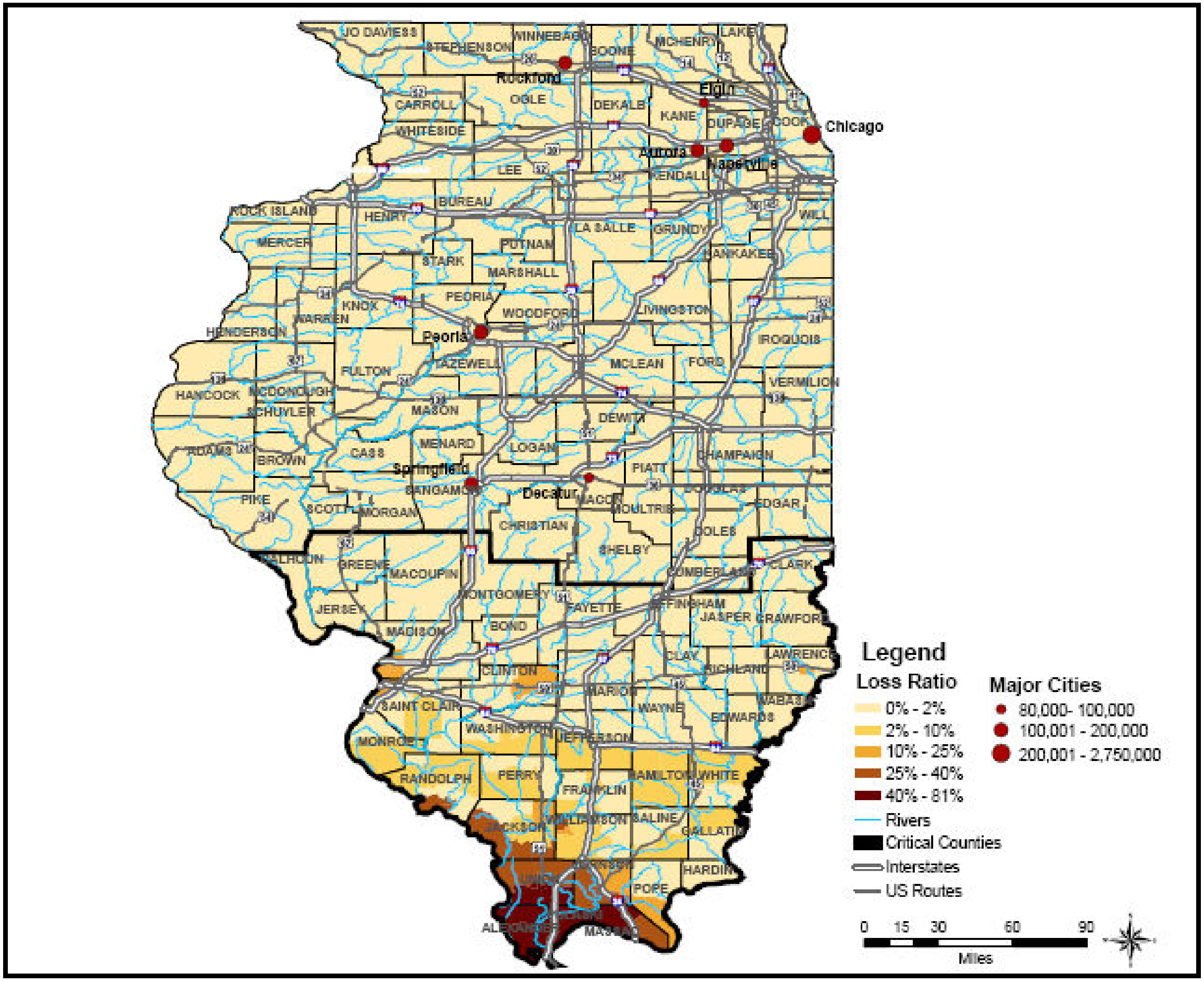

Figure 8: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 40 critical counties is illustrated in the following tables.

Table 37: Time-of-Day Casualties, 2:00 AM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Alexander	490	141	18	33	682
Bond	0	0	0	0	0
Calhoun	0	0	0	0	0
Clark	0	0	0	0	0
Clay	2	0	0	0	2
Clinton	69	19	2	4	94
Crawford	0	0	0	0	0
Edwards	1	0	0	0	1
Effingham	0	0	0	0	0
Fayette	0	0	0	0	0
Franklin	39	9	1	2	51
Gallatin	4	1	0	0	5
Greene	0	0	0	0	0
Hamilton	8	2	0	0	10
Hardin	1	0	0	0	1
Jackson	327	91	10	19	447
Jasper	0	0	0	0	0
Jefferson	26	5	0	1	32
Jersey	0	0	0	0	0
Johnson	169	42	5	10	226
Lawrence	61	17	2	4	84
Macoupin	1	0	0	0	1
Madison	577	162	18	33	790
Marion	5	0	0	0	5
Massac	485	135	17	31	668
Monroe	10	2	0	0	12
Montgomery	0	0	0	0	0
Perry	26	6	1	1	34
Pope	14	3	0	1	18
Pulaski	314	89	11	22	436
Randolph	138	38	4	8	188
Richland	0	0	0	0	0
Saint Clair	832	228	25	46	1,131
Saline	15	3	0	0	18
Union	673	195	27	53	948
Wabash	28	7	1	1	37
Washington	7	1	0	0	8
Wayne	1	0	0	0	1
White	13	3	0	0	16
Williamson	142	37	4	7	190

Table 38: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Alexander	9,590	5,633	1,743
Bond	17,633	0	0
Calhoun	5,084	0	0
Clark	17,008	0	0
Clay	14,560	1	0
Clinton	35,535	1,016	211
Crawford	20,452	0	0
Edwards	6,971	0	0
Effingham	34,264	0	0
Fayette	21,802	0	0
Franklin	39,018	417	114
Gallatin	6,445	25	7
Greene	14,761	0	0
Hamilton	8,621	77	20
Hardin	4,800	0	0
Jackson	59,612	4,090	1,133
Jasper	10,117	0	0
Jefferson	40,045	188	53
Jersey	21,668	0	0
Johnson	12,878	1,689	378
Lawrence	15,452	763	201
Macoupin	49,019	0	0
Madison	258,941	7,706	1,914
Marion	41,691	2	0
Massac	15,161	5,412	1,418
Monroe	27,619	81	17
Montgomery	30,652	0	0
Perry	23,094	290	76
Pope	4,413	81	22
Pulaski	7,348	3,562	1,166
Randolph	33,893	1,819	404
Richland	16,149	0	0
Saint Clair	256,082	9,696	3,507
Saline	26,733	107	29
Union	18,293	6,445	1,693
Wabash	12,937	329	82
Washington	15,148	38	9
Wayne	17,151	0	0
White	15,371	110	29
Williamson	61,296	1,804	480

Table 39: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Alexander	104,580	836,640	61,005	97,608	24,402
Bond	0	0	0	0	0
Calhoun	0	0	0	0	0
Clark	0	0	0	0	0
Clay	0	0	0	0	0
Clinton	12,660	101,280	7,385	11,816	2,954
Crawford	0	0	0	0	0
Edwards	0	0	0	0	0
Effingham	0	0	0	0	0
Fayette	0	0	0	0	0
Franklin	6,840	54,720	3,990	6,384	1,596
Gallatin	420	3,360	245	392	98
Greene	0	0	0	0	0
Hamilton	1,200	9,600	700	1,120	280
Hardin	0	0	0	0	0
Jackson	67,980	543,840	39,655	63,448	15,862
Jasper	0	0	0	0	0
Jefferson	3,180	25,440	1,855	2,968	742
Jersey	0	0	0	0	0
Johnson	22,680	181,440	13,230	21,168	5,292
Lawrence	12,060	96,480	7,035	11,256	2,814
Macoupin	0	0	0	0	0
Madison	114,840	918,720	66,990	107,184	26,796
Marion	0	0	0	0	0
Massac	85,080	680,640	49,630	79,408	19,852
Monroe	1,020	8,160	595	952	238
Montgomery	0	0	0	0	0
Perry	4,560	36,480	2,660	4,256	1,064
Pope	1,320	10,560	770	1,232	308
Pulaski	69,960	559,680	40,810	65,296	16,324
Randolph	24,240	193,920	14,140	22,624	5,656
Richland	0	0	0	0	0
Saint Clair	210,420	1,683,360	122,745	196,392	49,098
Saline	1,740	13,920	1,015	1,624	406
Union	101,580	812,640	59,255	94,808	23,702
Wabash	4,920	39,360	2,870	4,592	1,148
Washington	540	4,320	315	504	126
Wayne	0	0	0	0	0
White	1,740	13,920	1,015	1,624	406
Williamson	28,800	230,400	16,800	26,880	6,720

Table 40: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Alexander	114.90	117.62	232.52
Bond	0.30	0.04	0.34
Calhoun	0.12	0.01	0.13
Clark	0.33	0.05	0.38
Clay	3.28	1.50	4.78
Clinton	18.42	18.47	36.89
Crawford	0.37	0.04	0.41
Edwards	1.76	0.95	2.71
Effingham	0.75	0.12	0.87
Fayette	0.41	0.06	0.47
Franklin	17.42	10.23	27.65
Gallatin	2.29	1.00	3.29
Greene	0.27	0.03	0.30
Hamilton	3.93	2.38	6.31
Hardin	1.39	0.35	1.74
Jackson	83.57	76.94	160.51
Jasper	0.18	0.02	0.20
Jefferson	15.59	8.87	24.46
Jersey	0.40	0.05	0.45
Johnson	58.09	57.11	115.20
Lawrence	17.90	19.31	37.21
Macoupin	0.91	0.11	1.02
Madison	133.31	122.96	256.27
Marion	5.62	1.82	7.44
Massac	132.86	143.30	276.16
Monroe	6.19	2.35	8.54
Montgomery	0.55	0.06	0.61
Perry	10.95	7.42	18.37
Pope	8.54	6.82	15.36
Pulaski	81.32	88.54	169.86
Randolph	37.57	36.80	74.37
Richland	0.32	0.04	0.36
Saint Clair	192.04	155.48	347.52
Saline	10.24	5.14	15.38
Union	181.59	210.01	391.60
Wabash	9.16	7.54	16.70
Washington	5.08	2.13	7.21
Wayne	1.24	0.36	1.60
White	7.45	3.74	11.19
Williamson	47.88	33.57	81.45

Indiana – New Madrid Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate approximately 282 thousand tons of debris, which will require 11,280 truckloads, each with 25-ton capacity, to remove the debris. Of the debris, 73 percent (205 thousand tons) will be brick, wood, and building contents, with steel and concrete comprising the balance (77 thousand tons).

There are roughly 6.1 million people that reside in the State of Indiana. A M_w7.7 event in the NMSZ displaces 60 people with the majority of those people living in the 11 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Indiana it is estimated that 14 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 6,720 square feet of shelter space will be required, with 840 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 14 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 98 gallons of water, 784 pounds of ice, and 196 MRE's (meals ready to eat) in total. Quantities are displayed for the 11 critical counties for feeding, ice, and sleeping space requirements.

Table 41: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
11 Critical Counties	480,752	52	13
Remaining Counties	5,599,733	6	1
Total State	6,080,485	58	14

Table 42: Worst Case Casualties - Event Occurs at 5:00 PM

Worst Case Casualties (5:00 PM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
11 Critical Counties	57	12	12	2	83
Other Remaining Counties	53	4	4	1	62
Total State	110	16	16	3	145

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The NMSZ event in Indiana results in the greatest number of casualties if the event occurs at 5:00 PM. A total of 145 casualties are expected from this event. There are 3 estimated fatalities while roughly 110 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

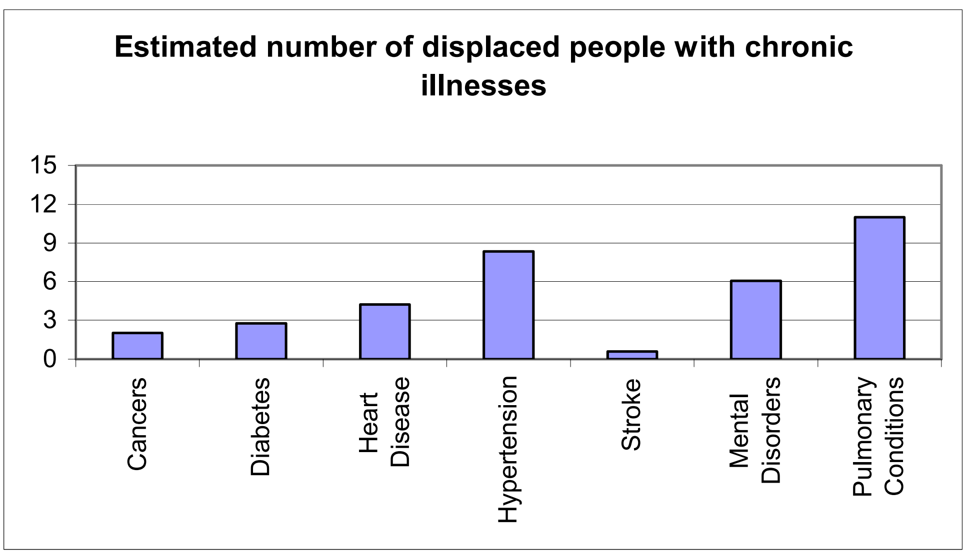

Figure 9: Estimated Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (60 people) and the prevalence of chronic conditions within Indiana (Milken Institute, 2007), it is estimated that there will be approximately 8 chronic cases that need to be cared for within

the displaced population. It is possible that a person may suffer from more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation, and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 10 illustrates the building loss ratios for the entire state due to a M_w7.7 event in the NMSZ. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratio is estimated at roughly 2%, and occurs in the southern Vanderburgh County where shaking is most intense. Additional southwestern counties show loss ratios between 1% and 2% where shaking is moderate. Loss ratios this low are not considered significant since only a small portion of the building value is lost. Also of particular interest is the level of non-structural damage, which totals nearly $300 million, or nearly 50%, of total building losses. Structural losses only contribute to 16% of all building losses. The remaining building losses are attributed to non-structural contents and business interruption losses.

Total direct economic losses for the state reach approximately $1.4 billion from the NMSZ M_w7.7 event. A large portion of losses, $613 million, or 43% of total direct losses, are attributed to building losses (see Table 46). Utility losses also contribute significantly to total losses, with $648 million in utility losses alone, or 46% of all direct economic losses. Transportation losses contribute far less, with roughly 11% of the total losses.

Table 43: Direct Building Losses ($ millions)

Direct Building Losses ($ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.00	0.30	15.38	0.78	0.99	17.44
Capital-Related	0.00	0.13	12.37	0.51	0.78	13.78
Rental	3.65	3.52	6.56	0.23	0.29	14.26
Relocation	0.35	0.12	0.42	0.03	0.16	1.08
Subtotal	4.00	4.07	34.73	1.54	2.22	46.57
Capital Stock Loses						
Structural	28.74	12.27	15.50	3.91	38.32	98.74
Non-Structural	133.94	57.21	53.07	17.96	33.33	295.51
Content	68.73	18.67	35.47	12.82	27.23	162.92
Inventory	0.00	0.00	1.36	3.06	4.60	9.02
Subtotal	231.42	88.14	105.40	37.75	103.48	566.19
Total	235.42	92.21	140.13	39.29	105.70	**612.75**

Table 44: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments Bridges Tunnels	70,249.58 10,749.46 0.00	19.83 23.35 0.00	0.03 0.22 0.00
Railways	Segments Bridges Facilities	6,475.16 10.40 204.33	1.84 0.00 7.85	0.03 0.00 3.84
Bus	Facilities	51.64	1.09	2.11
Ferry	Facilities	0.00	0.00	0.00
Port	Facilities	196.40	9.97	5.08
Airport	Facilities Runways	2,784.30 17,222.67	60.57 4.44	2.18 0.03
Total		**107,973.10**	**158.10**	

Table 45: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities Distribution Lines	3,292.70 3,587.60	17.78 8.79	0.54 0.24
Waste Water	Facilities Distribution Lines	30,594.70 2,152.50	127.60 6.95	0.42 0.32
Natural Gas	Facilities ALL Pipelines	32.60 8,592.60	0.15 7.74	0.47 0.09
Oil Systems	Facilities	17.50	0.18	1.05
	Regional Pipelines	2,672.20	0.31	0.01
Electrical Power	Facilities	89,733.60	467.67	0.52
Communication	Facilities	2,232.90	10.71	0.48
Total		142,809.89	647.88	

Table 46: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings **Transportation** **Utility**	$380,969,000,000 $107,793,100,000 $142,908,890,000	$612,750,000 $158,100,000 $647,880,000
Total	**$631,670,990,000**	**$1,418,730,000**

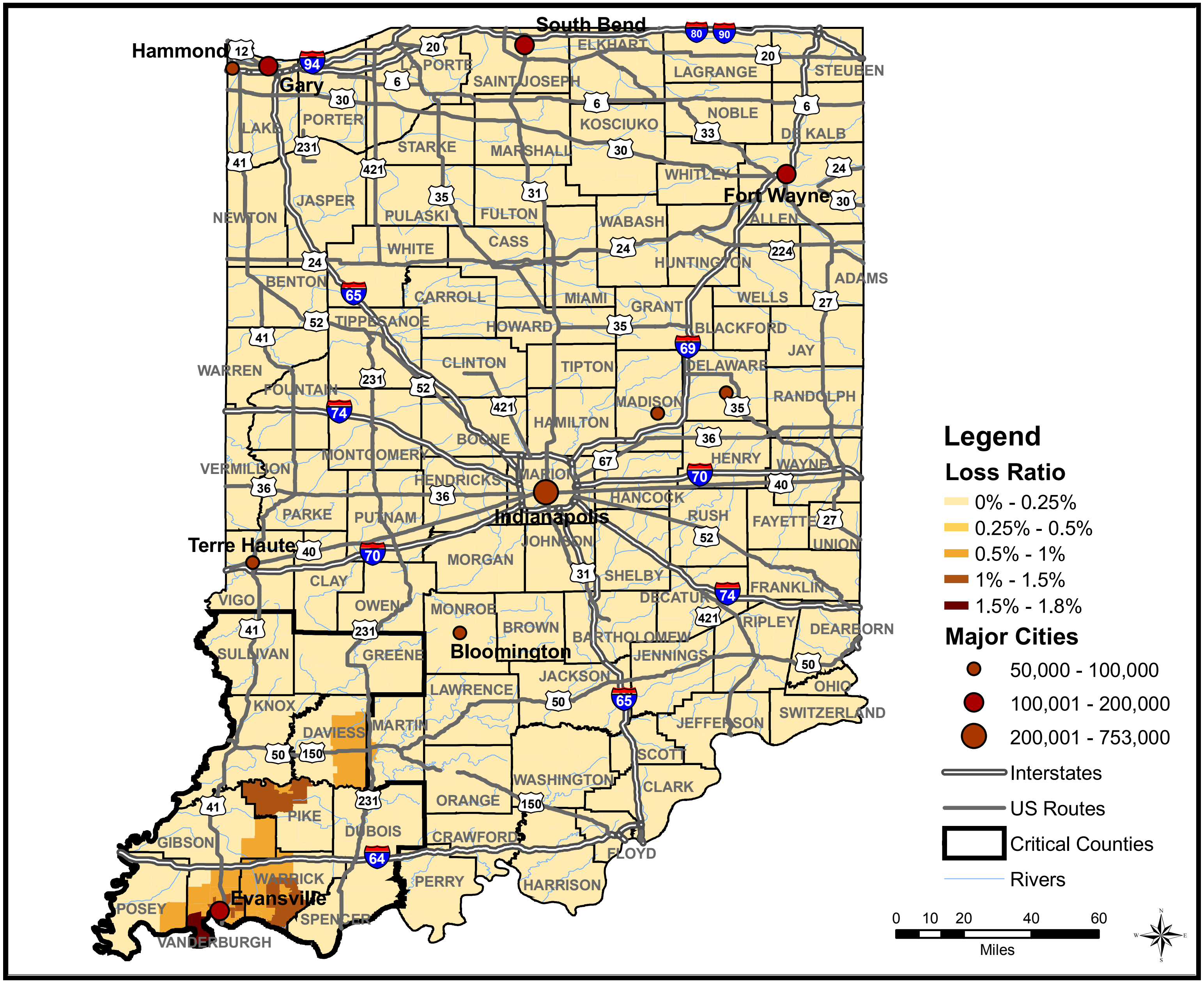

Figure 10: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 11 critical counties is illustrated in the following tables.

Table 47: Time-of-Day Casualties, 5:00 PM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Daviess	2	0	0	0	2
Dubois	0	0	0	0	0
Gibson	2	1	1	0	4
Greene	0	0	0	0	0
Knox	0	0	0	0	0
Pike	1	0	0	0	2
Posey	1	1	1	0	3
Spencer	0	0	0	0	0
Sullivan	0	0	0	0	0
Vanderburgh	42	8	8	2	61
Warrick	9	2	2	0	12

Table 48: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Daviess	29,820	0	0
Dubois	39,674	0	0
Gibson	32,500	0	0
Greene	33,157	0	0
Knox	39,256	0	0
Pike	12,837	0	0
Posey	27,061	0	0
Spencer	20,391	0	0
Sullivan	21,751	0	0
Vanderburgh	171,922	48	12
Warrick	52,383	4	1

Table 49: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Daviess	0	0	0	0	0
Dubois	0	0	0	0	0
Gibson	0	0	0	0	0
Greene	0	0	0	0	0
Knox	0	0	0	0	0
Pike	0	0	0	0	0
Posey	0	0	0	0	0
Spencer	0	0	0	0	0
Sullivan	0	0	0	0	0
Vanderburgh	5,760	720	420	672	168
Warrick	480	60	35	56	14

Table 50: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Daviess	2.16	0.75	2.91
Dubois	0.78	0.13	0.91
Gibson	2.08	0.53	2.61
Greene	0.62	0.08	0.70
Knox	0.72	0.10	0.82
Pike	1.97	0.65	2.62
Posey	1.45	0.21	1.65
Spencer	0.39	0.05	0.43
Sullivan	0.34	0.04	0.38
Vanderburgh	84.73	58.73	143.47
Warrick	12.01	3.45	15.45

Indiana – Wabash Valley Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate approximately 1.76 million tons of debris, which will require 70,000 truckloads, each with 25-ton capacity to remove. Of the debris, 47% (826 thousand tons) will be brick, wood, and building contents, with steel and concrete comprising the balance (933 thousand tons).

There are roughly 6.1 million people that reside in the State of Indiana. A M_w7.1 event in the WVSZ displaces over 27,600 people with the majority of those people living in the 11 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Indiana it is estimated that approximately 7,000 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 3,372,960 square feet of shelter space will be required, with 421,620 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 7,000 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 245,945 gallons of water, 393,512 pounds of ice, and 5 truckloads of 98,378 MRE's (meals ready to eat) in total. Quantities are displayed for the 11 critical counties for feeding, ice, and sleeping space requirements.

Table 51: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
11 Critical Counties	480,752	26,721	6,815
Remaining Counties	5,599,733	899	212
Total State	6,080,485	27,620	7,027

Table 52: Worst Case Casualties - Event Occurs at 2:00 AM

Worst Case Casualties (2:00 AM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
11 Critical Counties	2,012	572	64	118	2,766
Other Remaining Counties	193	24	1	3	221
Total State	2,205	596	65	121	2,987

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The WVSZ event in Indiana results in the greatest number of casualties if the event occurs at 2:00 AM. A total of 2,987 casualties are expected from this event. There are 121 estimated fatalities and roughly 2,200 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

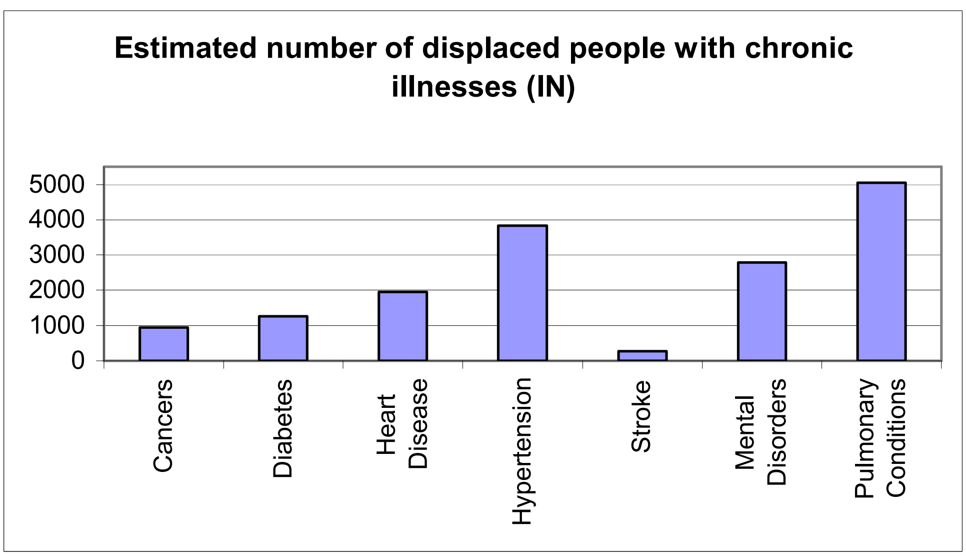

Figure 11: Estimated Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (27,620 people) and the prevalence of chronic conditions within Indiana (Milken Institute, 2007), it is estimated that there will be approximately 16,130 chronic cases that need to be cared

for within the displaced population. It is possible that a person may suffer from more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Figure 12 illustrates the building loss ratios for the entire state due to the M_w7.1 event on the Wabash Valley Fault. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratio is estimated at roughly 27%, and occurs in western Knox County. Additionally, Gibson County, where shaking is slightly less severe, shows loss ratios between 10% and 20%. More common loss ratios are below 2%, and are not considered significant since only a small portion of the building value is lost. Also of particular interest is the level of non-structural damage, which totals over $2.1 billion, or over 50% of total building losses. Structural losses only contribute to 16% of all building losses. The remaining building losses are attributed to non-structural contents and business interruption losses.

Total direct economic losses for the state are greater than $7.2 billion from the Wabash Valley M_w7.1 event. The building losses total $3.9 billion, or 54% of total direct losses. Utility losses also contribute a significant portion to total losses as well, with $2.94 billion in losses, or 41% of all direct economic losses. Transportation losses contribute far less, with roughly 5% of the total losses.

Table 53: Direct Building Losses ($ millions)

Direct Building Losses ($ millions)						
	Single Family	**Other Residential**	**Commercial**	**Industrial**	**Others**	**Total**
Business Interruption Loses						
Wage	0.00	6.84	62.61	1.98	5.77	77.20
Capital-Related	0.00	3.10	48.71	1.20	9.32	62.34
Rental	49.78	41.77	20.64	0.61	1.62	114.43
Relocation	5.40	0.89	1.64	0.05	0.74	8.72
Subtotal	55.19	52.59	133.60	3.85	17.45	262.68
Capital Stock Losses						
Structural	286.32	69.38	66.47	10.68	201.97	634.82
Non-Structural	1,087.65	412.33	275.95	64.10	266.43	2,106.45
Content	367.17	112.13	164.83	43.53	185.63	873.28
Inventory	0.00	0.00	5.78	10.74	33.78	50.30
Subtotal	1,741.13	593.84	513.03	129.04	687.81	3,664.85
Total	1,796.32	646.44	646.63	132.89	705.26	**3,927.53**

Table 54: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments	70,249.58	107.98	0.15
	Bridges	10,749.46	49.12	0.46
	Tunnels	0.00	0.00	0.00
Railways	Segments	6,475.16	9.07	0.14
	Bridges	10.40	0.00	0.00
	Facilities	204.33	8.77	4.29
Bus	Facilities	51.64	3.78	7.32
Ferry	Facilities	0.00	0.00	0.00
Port	Facilities	196.40	10.34	5.26
Airport	Facilities	2,784.30	136.23	4.89
	Runways	17,222.67	30.58	0.18
Total		**107,973.10**	**385.10**	

Table 55: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	3,292.70	102.84	3.12
	Distribution Lines	3,587.60	28.19	0.79
Waste Water	Facilities	30,594.70	573.33	1.87
	Distribution Lines	2,152.50	22.30	1.04
Natural Gas	Facilities	32.60	0.64	1.96
	ALL Pipelines	8,592.60	24.33	0.28
Oil Systems	Facilities	17.50	0.51	2.89
	Regional Pipelines	2,672.20	1.09	0.04
Electrical Power	Facilities	89,733.60	2,138.72	2.38
Communication	Facilities	2,232.90	44.30	1.98
Total		**142,809.89**	**2,936.55**	

Table 56: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$380,969,000,000	$3,927,530,000
Transportation	$107,793,100,000	$385,100,000
Utility	$142,908,890,000	$2,936,550,000
Total	**$631,670,990,000**	**$7,249,180,000**

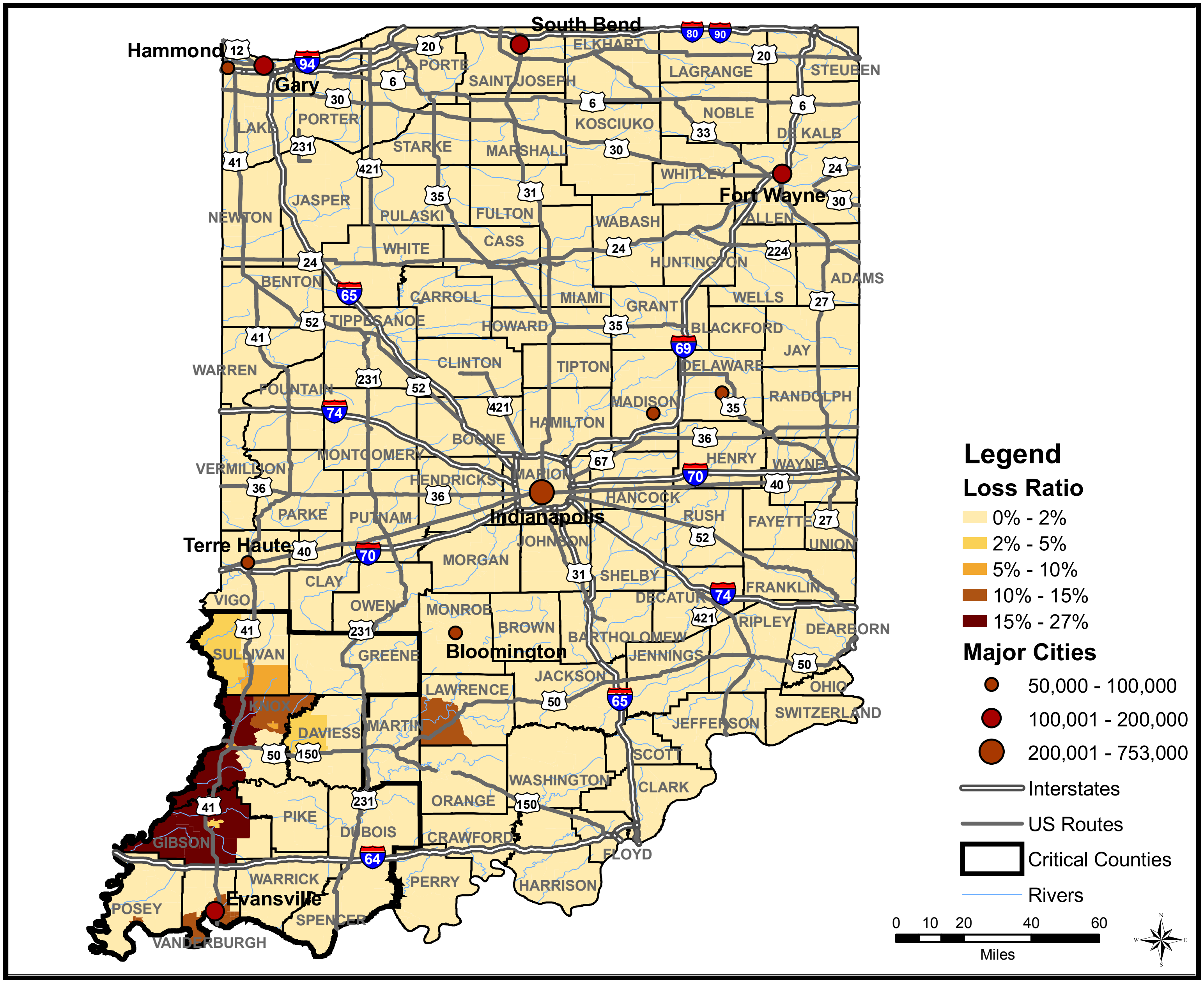

Figure 12: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 11 critical counties is illustrated in the following tables.

Table 57: Time-of-Day Casualties, 2:00 AM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Daviess	11	2	0	0	13
Dubois	5	0	0	0	5
Gibson	338	94	10	18	460
Greene	0	0	0	0	0
Knox	504	145	16	31	696
Pike	1	0	0	0	1
Posey	75	20	2	4	101
Spencer	0	0	0	0	0
Sullivan	15	4	0	1	20
Vanderburgh	1,063	306	35	65	1,469
Warrick	0	0	0	0	0

Table 58: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Daviess	29,820	109	26
Dubois	39,674	3	1
Gibson	32,500	4,621	1,037
Greene	33,157	0	0
Knox	39,256	6,646	1,854
Pike	12,837	0	0
Posey	27,061	1,030	240
Spencer	20,391	0	0
Sullivan	21,751	86	39
Vanderburgh	171,922	14,226	3,618
Warrick	52,383	0	0

Table 59: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Daviess	12,480	1,560	910	1,456	364
Dubois	480	60	35	56	14
Gibson	497,760	62,220	36,295	58,072	14,518
Greene	0	0	0	0	0
Knox	889,920	111,240	64,890	103,824	25,956
Pike	0	0	0	0	0
Posey	115,200	14,400	8,400	13,440	3,360
Spencer	0	0	0	0	0
Sullivan	18,720	2,340	1,365	2,184	546
Vanderburgh	1,736,640	217,080	126,630	202,608	50,652
Warrick	0	0	0	0	0

Table 60: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Daviess	6.00	2.79	8.79
Dubois	7.56	2.01	9.57
Gibson	77.77	75.35	153.12
Greene	0.28	0.02	0.30
Knox	119.54	139.15	258.69
Pike	0.69	0.11	0.80
Posey	21.08	18.24	39.33
Spencer	0.18	0.01	0.20
Sullivan	5.10	2.07	7.17
Vanderburgh	364.06	644.76	1,008.82
Warrick	0.39	0.02	0.41

Kentucky – New Madrid Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate 4 million tons of debris, which will require 160,000 truckloads, each with 25-ton capacity, to remove. Of the debris, 48% (1.92 million tons) will be bricks, wood, and building contents, with steel and concrete comprising the balance (2.08 million tons).

There are roughly 4.0 million people that reside in the State of Kentucky. A M_w7.7 event in the NMSZ displaces nearly 78,200 people with the majority of those people living in the 25 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Kentucky it is estimated that nearly 20,700 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 9,918,240 square feet will be required, with 1,239,780 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 20,663 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 723,205 gallons of water, 1,157,128 pounds of ice, and approximately 14 truckloads of MREs (meals ready to eat), 289,282 in total. Quantities are displayed for the 25 critical counties for feeding, ice, and sleeping space requirements.

Table 61: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
25 Critical Counties	655,184	52,964	13,904
Remaining Counties	3,386,585	25,225	6,759
Total State	4,041,769	78,189	20,663

Table 62: Worst Case Casualties - Event Occurs at 2:00 PM

Worst Case Casualties (2:00 PM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
25 Critical Counties	6,722	2,051	318	593	9,684
Other Remaining Counties	49	5	1	0	56
State Total	6,771	2,056	319	593	9,740

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2AM, the majority of the population is working at 2PM, and many people are commuting at 5PM. The NMSZ event in Kentucky results in the greatest number of casualties if the event occurs at 2PM. A total of 9,740 casualties are expected from this event. There are 593 estimated fatalities and those occur within the critical counties. It is very unlikely that fatalities occur outside the critical counties. Roughly 6,771 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

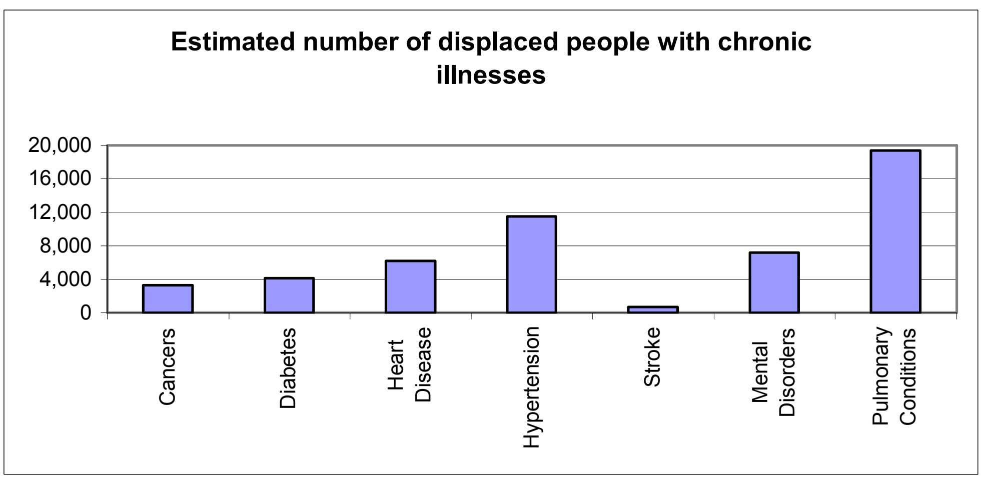

Figure 13: Estimates Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (78,189 people) and the prevalence of chronic conditions within Kentucky (Milken Institute, 2007), it is estimated that there will be approximately 52,387 chronic cases that need to be cared for within the displaced population. It is possible that a person may suffer from

more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation, and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 14 illustrates the building loss ratios for the entire state. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost, which can be skewed by greater building values in a census tract. The greatest loss ratios are estimated at 75%, and occur in the western Fulton and southern Ballard Counties where shaking is most intense. Additionally, portions of Carlisle, Graves, Marshall, and McCracken Counties show loss ratios between 40% and 60% where shaking is moderate. These loss ratios should be considered a concern since 40% to 60% of the total building value in a given census tract is lost. Ratios between 0% and 10% are expected in most of the remainder of the state. Non-structural damage, including damage to finishes, drywall, and flooring surfaces, total over \$5.34 billion or more 55% of total building losses. Structural losses only comprise 15% of all building economic losses. The remaining building losses are attributed to content and business interruption losses.

Total direct economic losses for the state reach over \$46.0 billion from the NMSZ M_w7.7 event. The majority of losses are attributed to utility losses, \$35.3 billion, or over 75% of total direct losses (see Table 66). Transportation and building losses contribute far less, with roughly 3% and 20% of the total losses, respectively.

Table 63: Direct Building Losses (\$ millions)

Direct Building Losses ($ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.00	21.89	252.48	6.52	9.08	289.97
Capital-Related	0.00	9.61	192.28	4.06	3.05	208.99
Rental	170.92	111.60	87.94	2.03	4.65	377.14
Relocation	19.15	3.03	6.20	0.21	1.46	30.04
Subtotal	190.06	146.14	538.90	12.81	18.23	906.14
Capital Stock Loses						
Structural	838.67	232.37	301.35	36.78	52.19	1,461.37
Non-Structural	3,028.44	1,017.46	979.86	168.45	141.34	5,335.55
Content	774.46	231.38	502.70	107.30	72.63	1,688.47
Inventory	0.00	0.00	23.66	24.53	3.22	51.41
Subtotal	4,641.57	1,481.22	1,807.57	337.06	269.38	8,536.80
Total	**4,831.64**	**1,627,36**	**2,346.47**	**349.87**	**287.61**	**9,442.94**

Table 64: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments	111,008.12	774.46	0.70
	Bridges	6,216.70	146.58	2.36
	Tunnels	18.54	0.00	0.00
Railways	Segments	4,004.74	33.77	0.84
	Bridges	18.21	0.21	1.15
	Facilities	249.96	43.76	17.51
Bus	Facilities	27.77	1.83	6.60
Light Rail	Segments	0.00	0.00	0.00
	Facilities	0.00	0.00	0.00
Ferry	Facilities	17.09	17.09	100.00
Port	Facilities	584.00	138.25	23.67
Airport	Facilities	1,169.68	98.28	8.40
	Runways	4,721.05	39.25	0.83
Total		**128,035.86**	**1,291.48**	

Table 65: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	5,841.50	220.82	3.78
	Distribution Lines	3,309.20	88.44	2.67
Waste Water	Facilities	592,633.40	24,220.98	4.09
	Distribution Lines	1,985.50	69.95	3.52
Natural Gas	Facilities	360.00	19.88	5.52
	Local Pipelines	1,323.70	74.77	5.65
	Regional Pipelines	7,495.50	5.61	0.07
Oil Systems	Facilities	8.60	0.55	6.42
	Regional Pipelines	918.10	1.86	0.20
Electrical Power	Facilities	182,505.40	10,516.63	5.76
Communication	Facilities	1,603.00	72.31	4.51
Total		**797,983.90**	**35,291.80**	

Table 66: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$259,784,000,000	$9,442,940,000
Transportation	$128,035,860,000	$1,291,480,000
Utility	$797,983,900,000	$35,291,800,000
Total	**$1,185,803,760,000**	**$46,026,220,000**

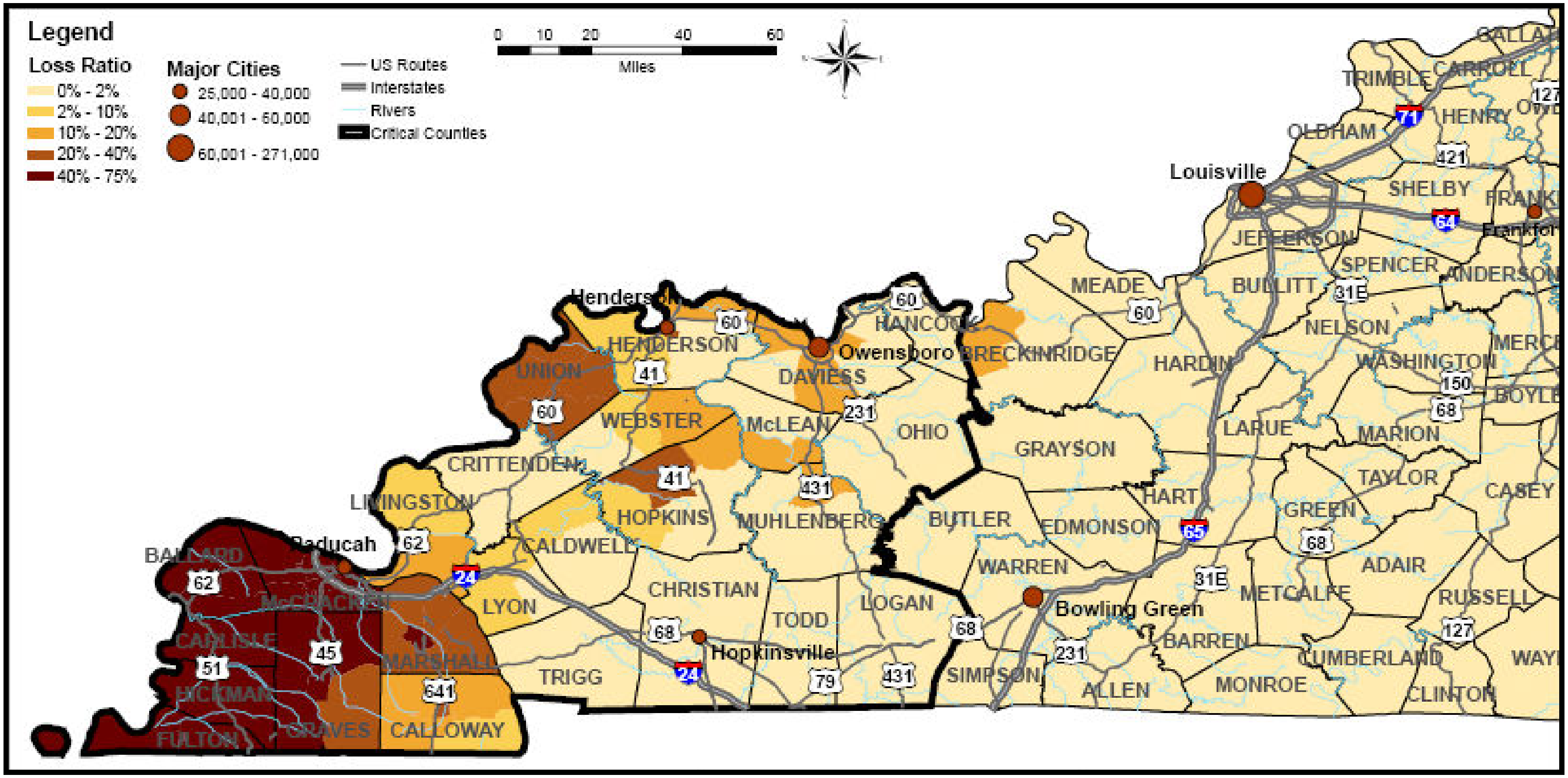

Figure 14: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 25 critical counties is illustrated in the following tables.

Table 67: Time-of-Day Casualties, 2:00 PM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Ballard	223	69	11	20	3223
Caldwell	3	1	0	0	4
Calloway	266	70	10	19	365
Carlisle	141	43	7	12	203
Christian	13	1	0	0	14
Crittenden	2	0	0	0	2
Daviess	507	157	23	43	730
Fulton	300	94	15	28	437
Graves	781	236	37	67	1,121
Hancock	0	0	0	0	0
Henderson	245	73	11	19	348
Hickman	122	38	6	11	177
Hopkins	94	26	4	6	130
Livingston	53	13	2	3	71
Logan	0	0	0	0	0
Lyon	14	4	0	1	19
Marshall	664	200	32	59	955
McCracken	3,022	945	149	283	4,399
McLean	12	3	0	1	16
Muhlenberg	56	17	2	4	79
Ohio	0	0	0	0	0
Todd	0	0	0	0	0
Trigg	2	0	0	0	2
Union	177	54	8	15	254
Webster	25	7	1	2	35

Table 68: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Ballard	8,286	3,113	805
Caldwell	13,060	20	5
Calloway	34,177	3,064	845
Carlisle	5,351	2,548	674
Christian	72,265	15	5
Crittenden	9,384	0	0
Daviess	91,545	9,697	2,362
Fulton	7,752	2,769	897
Graves	37,028	10,745	2,883
Hancock	8,392	0	0
Henderson	44,829	4,864	1,304
Hickman	5,262	1,779	498
Hopkins	46,519	2,453	584
Livingston	9,804	504	126
Logan	26,573	0	0
Lyon	8,080	212	60
Madison	70,872	0	0
Marshall	30,125	5,553	1,360
Mason	16,800	0	0
Muhlenberg	31,839	975	294
Ohio	22,916	0	0
Todd	11,971	0	0
Trigg	12,597	1	0
Union	15,637	3,907	1,010
Webster	14,120	745	192

Table 69: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Ballard	386,400	48,300	28,175	45,080	11,270
Caldwell	2,400	300	175	280	70
Calloway	405,600	50,700	29,575	47,320	11,830
Carlisle	323,520	40,440	23,590	37,744	9,436
Christian	2,400	300	175	280	70
Crittenden	0	0	0	0	0
Daviess	1,133,760	141,720	82,670	132,272	33,068
Fulton	430,560	53,820	31,395	50,232	12,558
Graves	1,383,840	172,980	100,905	161,448	40,362
Hancock	0	0	0	0	0
Henderson	625,920	78,240	45,640	73,024	18,256
Hickman	239,040	29,880	17,430	27,888	6,972
Hopkins	280,320	35,040	20,440	32,704	8,176
Livingston	60,480	7,560	4,410	7,056	1,764
Logan	0	0	0	0	0
Lyon	28,800	3,600	2,100	3,360	840
Madison	0	0	0	0	0
Marshall	652,800	81,600	47,600	76,160	19,040
Mason	0	0	0	0	0
Muhlenberg	141,120	17,640	10,290	16,464	4,116
Ohio	0	0	0	0	0
Todd	0	0	0	0	0
Trigg	0	0	0	0	0
Union	484,800	60,600	35,350	56,560	14,140
Webster	92,160	11,520	6,720	10,752	2,688

Table 70: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Ballard	86.9	96.2	183.1
Caldwell	3.3	1.4	4.7
Calloway	122.0	128.5	250.5
Carlisle	66.0	68.8	134.8
Christian	16.5	7.6	24.1
Crittenden	2.1	0.8	2.9
Daviess	158.0	175.4	333.4
Fulton	78.1	90.8	168.9
Graves	306.8	340.4	647.1
Hancock	0.1	0.0	0.1
Henderson	87.3	93.1	180.3
Hickman	50.5	51.3	101.8
Hopkins	49.1	40.5	89.6
Livingston	23.9	20.6	44.5
Logan	0.4	0.1	0.5
Lyon	6.3	4.8	11.1
Madison	215.2	227.1	442.3
Marshall	756.3	879.5	1,635.8
Mason	7.1	6.0	13.1
Muhlenberg	16.2	18.6	34.8
Ohio	0.3	0.0	0.4
Todd	0.2	0.0	0.2
Trigg	3.4	1.4	4.8
Union	65.6	71.6	137.1
Webster	14.4	12.6	27.1

Mississippi – New Madrid Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate approximately 2 million tons of debris, which will require 80,000 truckloads, each with 25-ton capacity. Of the debris, 42% (840 thousand tons) will be brick, wood, and building contents, with steel and concrete comprising the balance (1,160 thousand tons).

There are roughly 2.8 million people that reside in the State of Mississippi. A M_w7.7 event in the NMSZ displaces 21,000 people with the majority of those people living in the 25 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Mississippi it is estimated that 5,550 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 2,671,680 square feet will be required, with 333,960 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 5,550 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 39,000 gallons of water, 312,000 pounds of ice, and four truckloads of 78,000 MRE's (meals ready to eat) in total. Quantities are displayed for the 25 critical counties for feeding, ice, and sleeping space requirements.

Table 71: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
25 Critical Counties	748,030	20,832	5,555
Remaining Counties	2,096,628	34	11
Total State	2,844,658	20,866	5,566

Table 72: Worst Case Casualties - Event Occurs at 2:00 PM

Worst Case Casualties (2:00 PM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
25 Critical Counties	2,036	474	45	86	2,641
Other Remaining Counties	855	294	65	122	1,336
Total State	2,891	768	110	208	3,977

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The NMSZ event in Mississippi results in the greatest number of casualties if the event occurs at 2:00 PM. A total of 3,977 casualties are expected from this event. There are 208 estimated fatalities and roughly 2,891 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

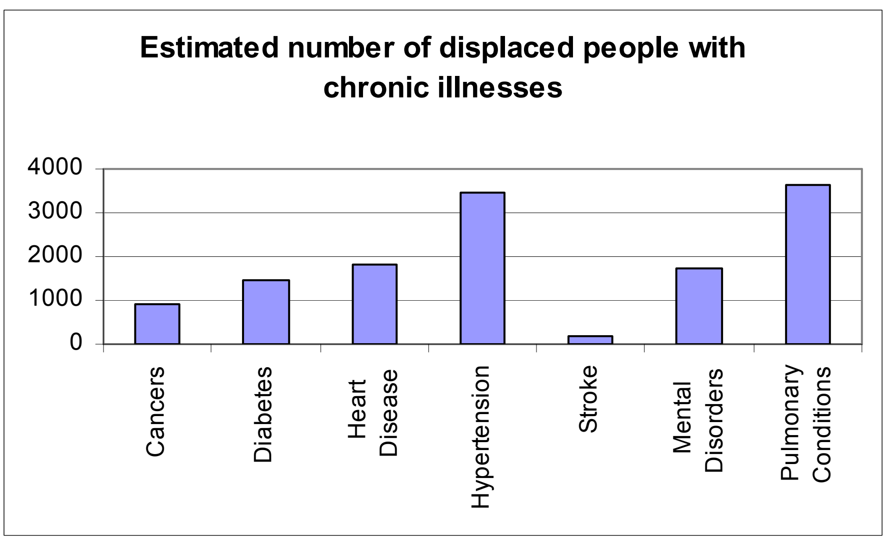

Figure 15: Displaced People with Chronic Illness

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (21,000 people) and the prevalence of chronic conditions within Mississippi (Milken Institute, 2007), it is estimated that there will be approximately 13,251 chronic cases that need to be cared for within the displaced population. It is possible that a person may suffer from

more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation, and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 16 illustrates the building loss ratios for the entire state. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratios are estimated at 33%, and occur in the northwestern Mississippi counties (Desoto, Tate, and Tunica) where shaking is most intense. Additionally, portions of Marshall and Lafayette Counties, where shaking is moderate, show loss ratios between 10% and 20%. These loss ratios should be considered a concern since 10% to 20% of the total building value in a given census tract is lost. It is more common to see ratios between 0% and 10% in the remainder of the state which is not as critical although still warrant consideration. Non-structural damage, including damage to finishes, drywall, and flooring surfaces, total nearly \$1.9 billion, or roughly half of total building losses. Structural losses only contribute to 15% of all building losses. The remaining building losses are attributed to non-structural contents damage and business interruption losses.

Table 73: Direct Building Losses (\$ millions)

Direct Building Losses (\$ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.00	28.23	166.29	25.07	11.27	230.86
Capital-Related	0.00	12.18	129.50	15.13	3.26	160.07
Rental	38.08	52.80	63.56	9.02	4.23	167.68
Relocation	4.09	1.54	4.40	0.37	1.50	11.91
Subtotal	42.17	94.76	363.75	49.59	20.26	570.53
Capital Stock Loses						
Structural	191.79	114.39	149.87	78.50	33.16	567.70
Non-Structural	793.46	375.21	383.84	222.06	80.76	1,855.33
Content	282.15	74.81	179.88	141.77	39.33	717.94
Inventory	0.00	0.00	9.65	47.64	1.20	58.49
Subtotal	1,267.40	564.41	723.23	489.96	154.45	3,199.46
Total	1,309.57	659.17	1,086.98	539.55	174.72	**3,769.99**

Total direct economic losses for the state reach over \$9.2 billion from the NMSZ M_w7.7 event. The majority of these losses are attributed to utility losses, in the amount of \$5.44 billion, or nearly 60% of total direct losses (see Table 76). Transportation and building losses contribute far less, with roughly 3% and 41% of the total losses, respectively.

Table 74: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments	48,744.44	84.84	0.17
	Bridges	10,003.59	81.01	0.81
	Tunnels	0.00	0.00	0.00
Railways	Segments	3,114.15	4.32	0.14
	Bridges	6.09	0.01	0.19
	Facilities	140.83	4.78	3.39
Bus	Facilities	37.06	1.84	4.97
Light Rail	Segments	0.00	0.00	0.00
	Facilities	0.00	0.00	0.00
Ferry	Facilities	0.00	0.00	0.00
Port	Facilities	498.48	16.94	3.40
Airport	Facilities	1,185.92	71.54	6.03
	Runways	5,415.69	14.45	0.27
Total		**69,176.25**	**279.73**	

Table 75: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	481.20	6.45	1.34
	Distribution Lines	3,419.10	32.97	0.96
Waste Water	Facilities	174,358.80	3,855.10	2.21
	Distribution Lines	2,051.50	26.08	1.27
Natural Gas	Facilities	384.50	9.04	2.35
	Local Pipelines	1,367.60	27.88	2.04
	Regional Pipelines	10,593.50	2.85	0.03
Oil Systems	Facilities	8.90	0.07	0.73
	Regional Pipelines	3,053.90	0.26	0.01
Electrical Power	Facilities	69,938.00	1,460.34	2.09
Communication	Facilities	783.40	20.89	2.67
Total		**266,440.45**	**5,441.93**	

Table 76: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$131,314,000,000	$3,769,990,000
Transportation	$69,176,250,000	$279,730,000
Utility	$266,440,450,000	$5,441,930,000
Total	**$466,930,700,000**	**$9,491,650,000**

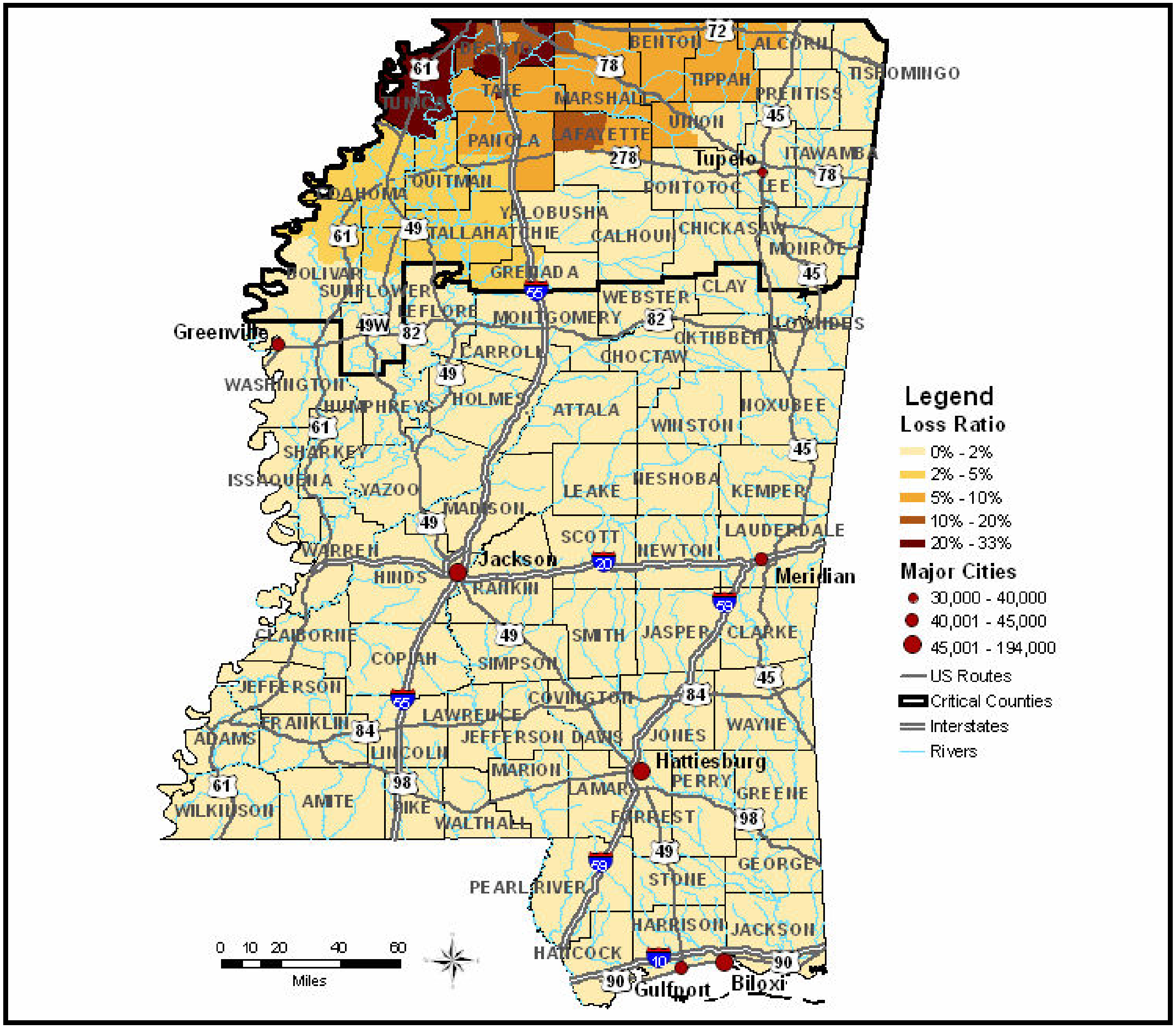

Figure 16: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 25 critical counties is illustrated in the following tables.

Table 77: Time-of-Day Casualties, 2:00 PM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Alcorn	19	3	0	0	23
Benton	26	5	0	1	33
Bolivar	18	3	0	0	21
Calhoun	3	0	0	0	3
Chickasaw	5	0	0	0	5
Coahoma	25	4	0	1	30
Desoto	926	240	25	46	1,237
Grenada	12	2	0	0	14
Itawamba	4	0	0	0	5
Lafayette	123	26	3	6	158
Lee	15	1	0	0	16
Marshall	147	30	3	5	184
Monroe	7	1	0	0	8
Panola	103	18	1	2	124
Pontotoc	5	0	0	0	6
Prentiss	5	0	0	0	6
Quitman	12	2	0	0	15
Sunflower	15	3	0	0	18
Tallahatchie	26	4	0	0	31
Tate	195	48	5	9	257
Tippah	58	11	1	2	71
Tishomingo	4	0	0	0	4
Tunica	252	68	7	13	340
Union	28	5	0	1	34
Yalobusha	3	0	0	0	3

Table 78: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Alcorn	34,558	101	28
Benton	8,026	211	68
Bolivar	40,633	125	49
Calhoun	15,069	1	0
Chickasaw	19,440	1	0
Coahoma	30,622	205	75
Desoto	107,199	11,438	2,556
Grenada	23,263	93	27
Itawamba	22,770	0	0
Lafayette	38,744	844	283
Lee	75,755	9	2
Marshall	34,993	1,318	391
Monroe	38,014	2	1
Panola	34,274	851	271
Pontotoc	26,726	1	0
Prentiss	25,556	2	1
Quitman	10,117	130	48
Sunflower	34,369	50	28
Tallahatchie	14,903	278	96
Tate	25,370	2,114	606
Tippah	20,826	359	102
Tishomingo	19,163	1	0
Tunica	9,227	2,494	869
Union	25,362	203	54
Yalobusha	13,051	1	0

Table 79: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Alcorn	13,440	1,680	980	1,568	392
Benton	32,640	4,080	2,380	3,808	952
Bolivar	23,520	2,940	1,715	2,744	686
Calhoun	0	0	0	0	0
Chickasaw	0	0	0	0	0
Coahoma	36,000	4,500	2,625	4,200	1,050
Desoto	1,226,880	153,360	89,460	143,136	35,784
Grenada	12,960	1,620	945	1,512	378
Itawamba	0	0	0	0	0
Lafayette	135,840	16,980	9,905	15,848	3,962
Lee	960	120	70	112	28
Marshall	187,680	23,460	13,685	21,896	5,474
Monroe	480	60	35	56	14
Panola	130,080	16,260	9,485	15,176	3,794
Pontotoc	0	0	0	0	0
Prentiss	480	60	35	56	14
Quitman	23,040	2,880	1,680	2,688	672
Sunflower	13,440	1,680	980	1,568	392
Tallahatchie	46,080	5,760	3,360	5,376	1,344
Tate	290,880	36,360	21,210	33,936	8,484
Tippah	48,960	6,120	3,570	5,712	1,428
Tishomingo	0	0	0	0	0
Tunica	417,120	52,140	30,415	48,664	12,166
Union	25,920	3,240	1,890	3,024	756
Yalobusha	0	0	0	0	0

Table 80: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Alcorn	14.62	8.88	23.50
Benton	12.68	11.47	24.15
Bolivar	10.42	9.63	20.04
Calhoun	3.06	1.61	4.67
Chickasaw	4.19	2.25	6.44
Coahoma	13.66	32.85	46.51
Desoto	360.68	533.81	894.49
Grenada	8.97	9.81	18.78
Itawamba	4.36	1.68	6.03
Lafayette	102.37	278.90	381.27
Lee	22.78	15.97	38.75
Marshall	64.19	64.34	128.53
Monroe	6.56	2.64	9.19
Panola	49.73	60.55	110.28
Pontotoc	4.94	2.29	7.24
Prentiss	5.23	2.17	7.40
Quitman	5.24	6.62	11.86
Sunflower	5.57	7.70	13.27
Tallahatchie	11.03	15.15	26.18
Tate	72.97	90.66	163.63
Tippah	39.79	50.79	90.58
Tishomingo	4.34	1.84	6.18
Tunica	58.03	64.04	122.07
Union	17.17	12.04	29.21
Yalobusha	2.40	0.77	3.17

Missouri – New Madrid Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate approximately 6 million tons of debris, which will require 240,000 truckloads, each with 25-ton capacity. Of the debris, 48 percent (2.9 million tons) will be brick, wood, and building contents, with steel and concrete comprising the balance (3.1 million tons).

There are roughly 5.6 million people that reside in the State of Missouri. A M_w7.7 event in the NMSZ displaces 122,000 people with the majority of those people living in the 46 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Missouri it is estimated that 36,700 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 17,617,000 square feet of shelter space will be required, with 2,202,000 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for 36,700 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 1,284,570 gallons of water, 2,055,312 pounds of ice, and 24 truckloads for a total of 513,828 MRE's (meals ready to eat) in total. Quantities are displayed for the 46 critical counties for feeding, ice, and sleeping space requirements.

Table 81: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
46 Critical Counties	3,043,805	121,927	36,702
Remaining Counties	2,551,406	2	2
Total State	5,595,211	121,929	36,704

Table 82: Worst Case Casualties - Event Occurs at 2:00 AM

Worst Case Casualties (2:00 AM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
46 Critical Counties	11,267	3,177	401	760	15,605
Remaining Counties	33	1	0	0	34
Total	11,300	3,178	401	760	15,639

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The NMSZ event in Missouri results in the greatest number of casualties if the event occurs at 2:00 AM. A total of 15,639 casualties are expected from this event. There are 760 estimated fatalities which occur within the critical counties. Additionally, about 11,300 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

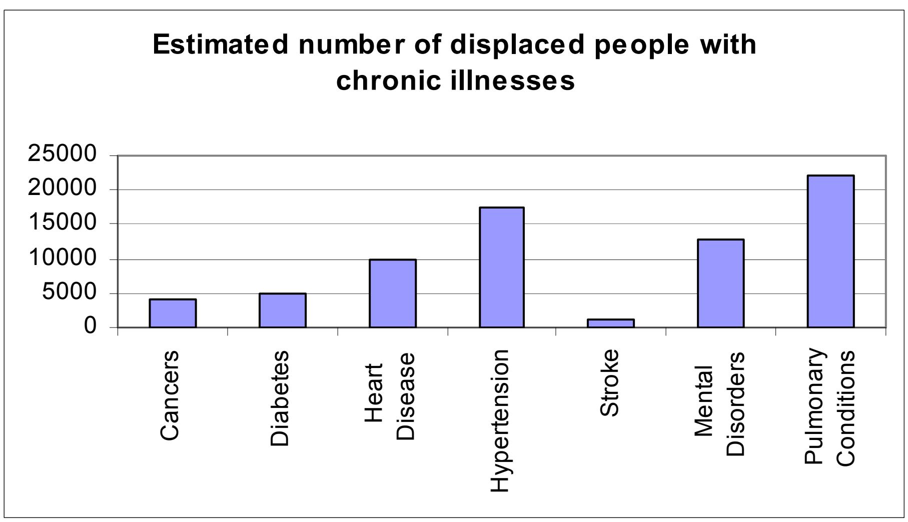

Figure 17: Estimated Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (121,928 people) and the prevalence of chronic conditions within Missouri (Milken Institute, 2007), it is estimated that there will be approximately 72,181 chronic cases that need to be cared for within the displaced population. It is possible that a person may suffer from more than

one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 18 illustrates the building loss ratios for the entire state. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratio is estimated at 91%, and occurs in western New Madrid and central Dunklin Counties where shaking is most intense. Other portions of these two counties also experience very high loss ratios. Additionally, Pemiscot, Stoddard, Butler and Scott Counties show significant loss ratios of 50% or more. Other counties in the southeastern portion of Missouri experience loss ratios greater than 20%, though ratios between 0% and 10% are expected in the remainder of the state. Non-structural damage, including damage to finishes, drywall, and flooring surfaces, total nearly $6.5 billion or over 55% of total building losses. Structural losses only contribute 15% of all building losses. The remaining building losses are attributed to content and business interruption losses.

Total direct economic losses for the State reach nearly $38.7 billion from the NMSZ M_w7.7 event. The majority of losses are attributed to utility losses, $25.1 billion, or nearly two-thirds of total direct losses (see Table 86). Transportation and building losses contribute far less, with roughly 5% and 31% of the total losses, respectively.

Table 83: Direct Building Losses ($ millions)

Direct Building Losses ($ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.00	39.70	338.40	11.53	19.36	408.99
Capital-Related	0.00	17.57	267.94	7.08	7.20	299.79
Rental	185.37	219.57	131.29	3.76	7.47	547.47
Relocation	20.49	5.23	8.48	0.29	2.67	37.18
Subtotal	205.87	282.07	746.12	22.67	36.69	1,293.42
Capital Stock Loses						
Structural	818.20	365.10	412.30	59.66	116.84	1,772.10
Non-Structural	2,807.49	1,777.17	1,322.23	259.97	288.66	6,455.52
Content	795.24	418.25	672.28	168.21	157.53	2,211.50
Inventory	0.00	0.00	28.49	41.02	9.36	78.89
Subtotal	4,420.92	2,560.51	2,435.31	528.87	572.40	10,518.00
Total	4,626.80	2,842.59	3,181.43	551.54	609.08	**11,811.43**

Table 84: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments	$82,631.70	$832.06	0.01
	Bridges	$14,588.52	$327.51	0.02
	Tunnels	$0.00	$0.00	0.00
Railways	Segments	$5,851.51	$70.29	0.01
	Bridges	$24.79	$0.35	0.01
	Facilities	$280.68	$39.13	0.14
Bus	Facilities	$80.83	$8.03	0.10
Light Rail	Segments	$18.26	$0.05	0.01
	Facilities	$38.17	$38.17	1.00
Ferry	Facilities	$8.98	$7.86	1.00
Port	Facilities	$496.38	$86.68	0.17
Airport	Facilities	$3,132.34	$223.34	0.07
	Runways	$14,085.45	$138.00	0.01
Total		**$121,237.61**	**$1,772.59**	

Table 85: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	$294,937.10	$14,585.64	0.05
	Distribution Lines	$5,340.80	$234.20	0.04
Waste Water	Facilities	$90,000.50	$3,624.10	0.04
	Distribution Lines	$3,204.50	$185.23	0.06
Natural Gas	Facilities	$397.50	$36.27	0.09
	Local Pipelines	$2,136.30	$198.01	0.09
	Regional Pipelines	$3,220.20	$7.94	0.00
Oil Systems	Facilities	$12.30	$1.96	0.03
	Regional Pipelines	$4,162.20	$0.33	0.00
Electrical Power	Facilities	$159,299.80	$6,170.69	0.04
Communication	Facilities	$2,149.80	$93.94	0.04
Total		**$564,861.00**	**$25,138.31**	

Table 86: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$334,877,000,000	$11,811,430,000
Transportation	$121,237,610,000	$1,772,590,000
Utility	$564,861,000,000	$25,138,310,000
Total	**$1,020,975,610,000**	**$38,722,330,000**

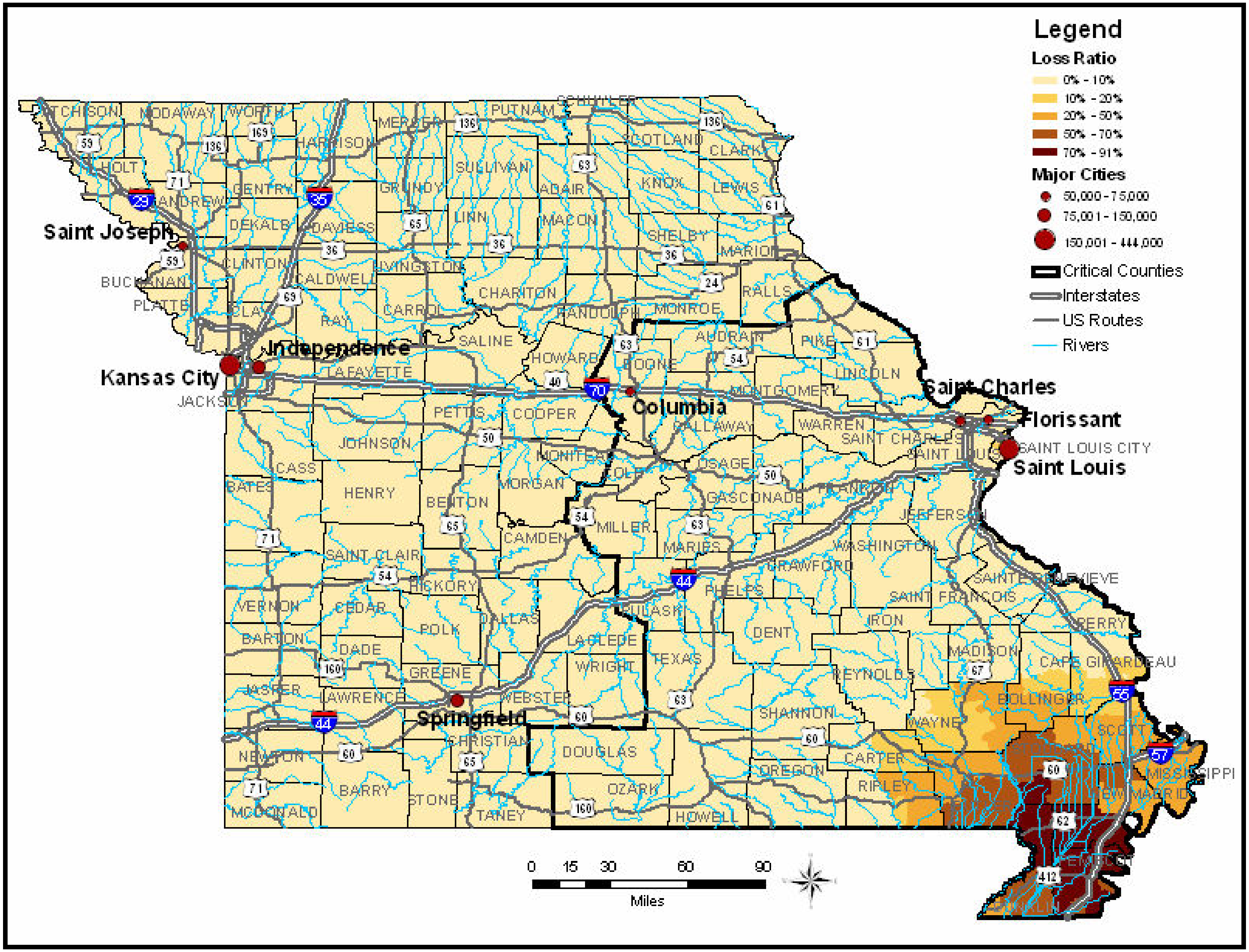

Figure 18: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 46 critical counties is illustrated in the following tables.

Table 87: Time-of-Day Casualties, 2:00 AM

Counties	Level I (Minor)	Level II (Moderate Injury-Delayed Attention)	Level III (Severe Injury-Immediate Attention)	Level IV (Fatality)	Total Casualties
Audrain	0	0	0	0	0
Bollinger	118	31	4	7	160
Boone	2	0	0	0	2
Butler	1,558	468	66	128	2,220
Callaway	1	0	0	0	1
Cape Girardeau	490	121	15	28	654
Carter	28	6	1	1	36
Cole	1	0	0	0	1
Crawford	0	0	0	0	0
Dent	0	0	0	0	0
Douglas	0	0	0	0	0
Dunklin	1,786	521	66	125	2,498
Franklin	2	0	0	0	2
Gasconade	0	0	0	0	0
Howell	1	0	0	0	1
Iron	3	0	0	0	3
Jefferson	72	14	2	2	90
Lincoln	1	0	0	0	1
Madison	12	3	0	1	16
Maries	0	0	0	0	0
Miller	0	0	0	0	0
Mississippi	314	85	10	18	427
Montgomery	0	0	0	0	0
New Madrid	893	254	31	59	1,237
Oregon	6	2	0	0	8
Osage	0	0	0	0	0
Ozark	0	0	0	0	0
Pemiscot	984	285	37	70	1,376
Perry	14	3	0	1	18
Phelps	1	0	0	0	1
Pike	0	0	0	0	0
Pulaski	1	0	0	0	1
Reynolds	7	2	0	0	9
Ripley	215	55	6	12	288
Saint Charles	3	0	0	0	3
Sainte Genevieve	5	0	0	0	5
Saint Francois	12	1	0	0	13
St. Louis City & St. Louis County	2,026	556	65	122	2,769
Scott	1,058	296	37	69	1,460
Shannon	3	0	0	0	3

Stoddard	1,490	435	57	109	2,091
Texas	1	0	0	0	1
Warren	0	0	0	0	0
Washington	5	0	0	0	5
Wayne	154	39	4	8	205

Table 88: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter-Seeking Population
Audrain	25,853	0	0
Bollinger	12,029	1,213	0
Boone	135,454	1	0
Butler	40,867	15,116	0
Callaway	40,766	0	127
Cape Girardeau	68,693	4,562	0
Carter	5,941	236	34
Cole	71,397	0	0
Crawford	22,804	0	0
Dent	14,927	0	1,160
Douglas	13,084	0	0
Dunklin	33,155	20,574	3,097
Franklin	93,807	0	17
Gasconade	15,342	0	0
Howell	37,238	0	0
Iron	10,,697	1	3,566
Jefferson	198,099	625	30
Lincoln	38,944	0	0
Madison	11,800	120	0
Maries	8,903	0	0
Miller	23,564	0	18
Mississippi	13,427	3,651	655
Montgomery	12,136	0	0
New Madrid	19,760	10,341	0
Oregon	10,344	54	1
Osage	13,062	0	510
Ozark	9,542	0	3,085
Pemiscot	20,047	10,911	0
Perry	18,132	123	4,483
Phelps	39,825	0	0
Pike	18,351	0	0
Pulaski	41,165	0	0
Reynolds	6,689	60	482
Ripley	13,509	2,182	7,316
St. Charles	283,883	0	0
Ste. Genevieve	17,842	1	0
St. Francois	55,641	5	0
St. Louis	1,016,315	1,866	0
Scott	40,422	11,221	127
Shannon	8,324	0	0
Stoddard	29,705	16,226	34
Texas	23,003	0	0
Warren	24,525	0	0
Washington	23,344	1	1,160
Wayne	13,259	1,714	0
St. Louis City	348,189	21,123	3,097

Table 89: Shelter Requirements

Counties	Total Space Required (ft.^{2})	Sleeping Space Required (ft.^{2})	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Audrain	0	0	0	0	0
Bollinger	157,920	0	0	0	0
Boone	0	0	0	0	0
Butler	2,055,360	0	0	0	0
Callaway	0	7,620	889	7,112	1,778
Cape Girardeau	560,160	0	0	0	0
Carter	36,480	2,040	238	1,904	476
Cole	0	0	0	0	0
Crawford	0	0	0	0	0
Dent	0	69,600	8120	64,960	16,240
Douglas	0	0	0	0	0
Dunklin	3,008,160	185,820	21,679	173,432	43,358
Franklin	0	1,020	119	952	238
Gasconade	0	0	0	0	0
Howell	0	0	0	0	0
Iron	0	213,960	24,962	199,696	49,924
Jefferson	60,960	1,800	210	1,680	420
Lincoln	0	0	0	0	0
Madison	16,320	0	0	0	0
Maries	0	0	0	0	0
Miller	0	1,080	126	1,008	252
Mississippi	556,800	39,300	4,585	36,680	9,170
Montgomery	0	0	0	0	0
New Madrid	1,486,560	0	0	0	0
Oregon	8,160	60	7	56	14
Osage	0	30,600	3,570	28,560	7,140
Ozark	0	185,100	21,595	172,760	43,190
Pemiscot	1,711,680	0	0	0	0
Perry	14,400	268,980	31,381	251,048	62,762
Phelps	0	0	0	0	0
Pike	0	0	0	0	0
Pulaski	0	0	0	0	0
Reynolds	8,640	28,920	3,374	26,992	6,748
Ripley	314,400	438,960	51,212	409,696	102,424
St. Charles	0	0	0	0	0
Ste. Genevieve	0	0	0	0	0
St. Francois	480	0	0	0	0
St. Louis	244,800	0	0	0	0
Scott	1,480,800	7,620	889	7,112	1,778
Shannon	0	0	0	0	0
Stoddard	2,151,840	2,040	238	1,904	476
Texas	0	0	0	0	0
Warren	0	0	0	0	0
Washington	0	69,600	8,120	64,960	16,240
Wayne	231,360	0	0	0	0
St. Louis City	3,511,680	185,820	21,679	173,432	43,358

Table 90: Total Debris

Counties	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
Audrain	1	0	1
Bollinger	39	34	73
Boone	3	0	3
Butler	418	554	971
Callaway	1	0	1
Cape Girardeau	207	218	425
Carter	12	9	22
Cole	1	0	2
Crawford	0	0	1
Dent	0	0	0
Douglas	0	0	0
Dunklin	397	444	841
Franklin	2	0	2
Gasconade	0	0	0
Howell	1	0	1
Iron	3	1	4
Jefferson	43	18	61
Lincoln	1	0	1
Madison	6	3	9
Maries	0	0	0
Miller	0	0	1
Mississippi	77	73	151
Montgomery	0	0	0
New Madrid	218	246	464
Oregon	3	1	4
Osage	0	0	0
Ozark	0	0	0
Pemiscot	235	290	525
Perry	9	5	14
Phelps	1	0	1
Pike	0	0	0
Pulaski	1	0	1
Reynolds	4	2	6
Ripley	70	74	145
Saint Charles	5	0	5
Saint Francois	12	4	17
Sainte Genevieve	6	2	8
Saint Louis	184	79	263
Saint Louis City	513	564	1,077
Scott	285	335	620
Shannon	2	1	3
Stoddard	344	377	721
Texas	0	0	1
Warren	0	0	1
Washington	4	1	5
Wayne	63	51	114

Tennessee – New Madrid Seismic Zone Scenario

Social and economic losses, as well as induced damage, result from direct damage to infrastructure. The social impacts included in this seismic impact assessment include displaced population estimates, food, ice, lodging and medical requirements for the shelter-seeking population, and casualty estimates.

Damage to the built environment will generate over 20.0 million tons of debris, which will require 800,000 truckloads, each with 25-ton capacity. Of the debris, 43% (8.8 million tons) will be brick, wood, and building contents, with steel and concrete comprising the balance (11.9 million tons).

There are roughly 5.7 million people that reside in the State of Tennessee. A M_w7.7 event in the NMSZ displaces nearly 263,000 people with the majority of those people living in the 37 critical counties. This estimate is only based on structural damage. If utility service interruptions are considered, the estimates of displaced people will be substantially greater. Based on the demographic makeup of Tennessee it is estimated that nearly 73,300 of the displaced residents will seek public shelter. The remainder of the displaced population will seek shelter with family or friends. To accommodate these people, a total area of 35,180,640 square feet of shelter space will be required, with 4,397,580 square feet utilized exclusively for sleeping. The balance of the area is reserved for supporting services. Space would be provided for approximately 73,300 beds or cots. For more detailed estimates of displaced population and the requirements of that population, please see the tables at the conclusion of this scenario discussion. During the first week post-event, the temporary shelter population will require 513,051 gallons of water, 4,104,408 pounds of ice, and 48 truckloads of 1,026,102 MRE's (meals ready to eat) in total. Quantities are displayed for the 37 critical counties for feeding, ice, and sleeping space requirements.

Table 91: Displaced and Shelter Seeking Population

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
37 Critical Counties	2,699,993	262,907	73,293
Remaining Counties	2,989,290	2	0
Total State	5,689,283	262,909	73,293

Table 92: Worst Case Casualties - Event Occurs at 2:00 PM

Worst Case Casualties (2:00 PM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
37 Critical Counties	31,913	9,706	1,544	2,904	46,067
Other Remaining Counties	11,419	3,759	609	1,184	16,971
Total State	43,332	13,465	2,153	4,088	63,038

Casualty estimates are determined for three times of day, which were chosen to represent three distributions of population. People are expected to be home and sleeping at 2:00 AM, the majority of the population is working at 2:00 PM, and many people are commuting at 5:00 PM. The NMSZ event in Tennessee results in the greatest number of casualties if the event occurs at 2:00 PM. A total of 63,038 casualties are expected from this event. There are 4,088 estimated fatalities and roughly 43,332 people are expected to experience minor injuries, termed a 'Level 1' casualty. The descriptions of each casualty severity level are listed below.

Casualties are reported with Simple Triage and Rapid Treatment (START) terminology. Severity levels are indicated by color, green for least severe, and black for a fatality. Listed below are HAZUS-MH MR2 "Severity Levels" and START classifications (colors) defined with descriptions of typical injuries for each severity level:

- Severity Level 1 (Green): Injuries will require rudimentary medical attention but hospitalization is not needed; injuries should be rechecked frequently.
- Severity Level 2 (Yellow): Injuries will require hospitalization but are not considered life-threatening.
- Severity Level 3 (Red): Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4 (Black): Victims are killed as a result of the earthquake.

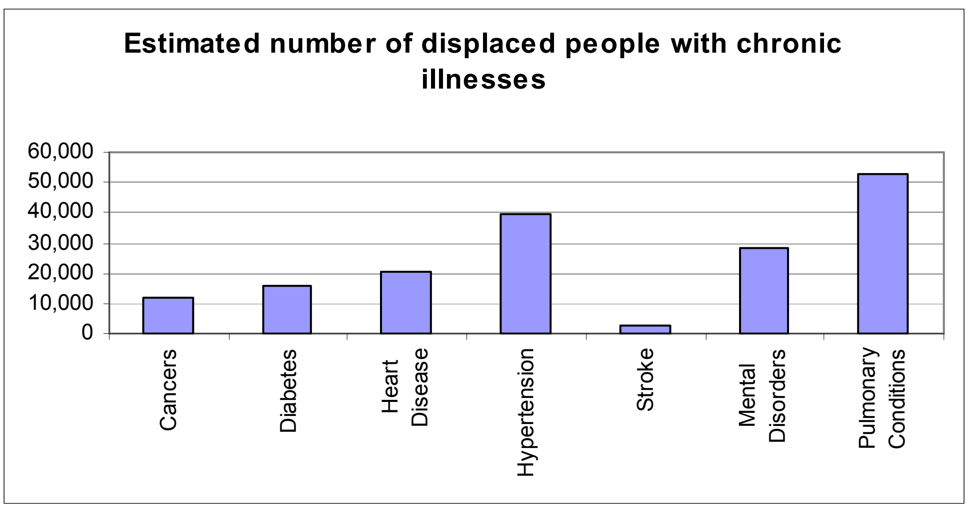

Figure 19: Estimates Number of Displaced People with Chronic Illnesses

In addition to acute illness, typically as a result of the disaster, the needs of the chronically ill are of critical importance to prevent an increase in the vulnerability of the population post-event. By combining estimates of the displaced population (262,909 people) and the prevalence of chronic conditions within Tennessee (Milken Institute, 2007), it is estimated that there will be approximately 170,365 chronic cases that need to be cared for within the displaced population. It is possible that a person may suffer from

more than one condition. Furthermore, medical needs such as eyeglasses, walkers, hearing aids, and dental care will also be required post-event.

Direct economic losses are determined for the three primary infrastructure groups; buildings, transportation, and utilities. Residential occupancy represents the largest portion of direct economic building loss in comparison to all other occupancy types. Figure 20 illustrates the building loss ratios for the entire state. Loss ratios indicate the percentage of building dollar value lost due to seismic activity. This percentage indicates the structural and non-structural building value lost in comparison to the total value of all buildings prior to damage. Loss ratios are an excellent indicator of relative economic loss because the value lost is correlated to the total value of buildings, as opposed to an absolute scale of dollar value lost which can be skewed by greater building values in a census tract. The greatest loss ratios are estimated at 62% and occur in the western Tipton County where shaking is most intense. Additionally, portions of Crockett and Weakley Counties show loss ratios between 30% and 40% where shaking is moderate. These loss ratios should be considered a concern since 30% to 40% of the total building value in a given census tract is lost. Ratios between 0% and 10% are expected in the remainder of the state. Non-structural damage, including damage to finishes, drywall, and flooring surfaces total over $21.5 billion, or more than half, of total building losses. Structural losses contribute to nearly 20% of all building losses. The remaining building losses are attributed to non-structural and business interruption losses.

Total direct economic losses for the state reach over $56.6 billion from the NMSZ M_w7.7 event. The majority of losses are attributed to building losses, $40.3 billion, or over 70% of total direct losses (see Table 96). Transportation and utility losses contribute far less, with roughly 3% and 26% of the total losses, respectively.

Table 93: Direct Building Losses ($ millions)

Direct Building Losses ($ millions)						
	Single Family	Other Residential	Commercial	Industrial	Others	Total
Business Interruption Loses						
Wage	0.00	120.87	1,574.04	52.16	52.44	1,799.51
Capital-Related	0.00	52.98	1,267.54	31.72	17.40	1,369.64
Rental	553.08	554.54	571.93	17.92	27.46	1,704.92
Relocation	59.55	12.11	39.59	1.56	9.29	122.11
Subtotal	592.63	740.50	3,453.10	103.36	106.60	4,996.18
Capital Stock Loses						
Structural	2,641.50	827.90	1,882.52	272.00	233.92	5,758.84
Non-Structural	9,662.90	4,071.83	5,883.14	1147.00	758.21	21,523.08
Content	2,736.12	934.58	2,858.46	727.76	366.32	7,623.24
Inventory	0.00	0.00	129.36	178.90	7.69	315.95
Subtotal	5,040.51	5,834.32	10,753.49	2,325.66	1,366.15	35,320.12
Total	5,633.14	6,574.82	14,206.58	2,429.02	1,472.74	**40,316.30**

Table 94: Direct Transportation Losses ($ millions)

Direct Transportation Losses ($ millions)				
Transportation System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Highway	Segments	63,750.02	663.40	1.04
	Bridges	7,319.62	561.51	7.67
	Tunnels	12.86	0.00	0.00
Railways	Segments	3,516.79	48.91	1.39
	Bridges	18.04	0.65	3.62
	Facilities	247.47	64.96	26.25
Bus	Facilities	48.92	5.39	11.02
Light Rail	Segments	3.09	0.03	1.01
	Facilities	0.00	0.00	0.00
Ferry	Facilities	5.76	5.76	100.00
Port	Facilities	388.04	111.75	28.80
Airport	Facilities	1,510.74	208.52	13.80
	Runways	5,634.18	75.62	1.34
Total		**82,455.53**	**1,746.23**	

Table 95: Direct Utility Losses ($ millions)

Direct Utility Losses ($ millions)				
Utility System	**Component**	**Inventory Value**	**Economic Loss**	**Loss Ratio (%)**
Potable Water	Facilities	2,871.80	181.50	6.32
	Distribution Lines	3,782.40	161.16	4.26
Waste Water	Facilities	114,051.20	10,671.34	9.36
	Distribution Lines	2,269.40	127.46	5.62
Natural Gas	Facilities	175.50	28.89	16.46
	Local Pipelines	1,513.00	136.25	9.01
	Regional Pipelines	5,081.50	9.91	0.20
Oil Systems	Facilities	10.60	1.27	11.94
	Regional Pipelines	820.00	2.62	0.32
Electrical Power	Facilities	41,430.40	3,123.57	7.54
Communication	Facilities	1,419.40	132.37	9.33
Total		**173,425.20**	**14,576.34**	

Table 96: Total Direct Economic Losses

Total Direct Economic Losses		
System	**Inventory Value**	**Total Direct Economic Loss**
Buildings	$329,827,000,000	$40,316,300,000
Transportation	$82,455,530,000	$1,746,230,000
Utility	$173,425,200,000	$14,576,340,000
Total	**$585,707,730,000**	**$56,638,870,000**

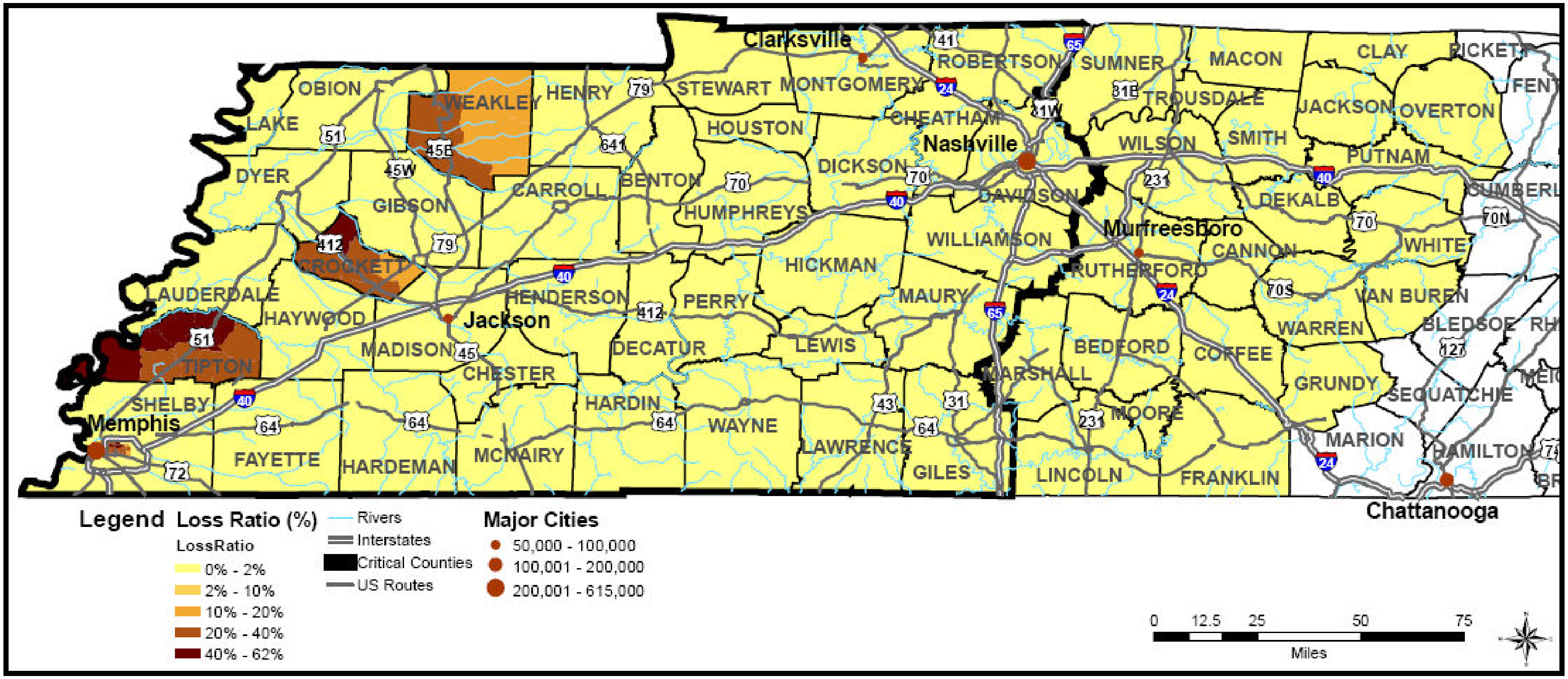

Figure 20: Loss Ratio (% of Total Building Assets)

Additional information on social impacts for the 37 critical counties is illustrated in the following tables.

Table 97: Worst-Case Casualties 2:00 PM

Counties	Level I (Minor)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
Benton	4	1	0	0	5
Carroll	144	35	5	8	192
Cheatham	0	0	0	0	0
Chester	49	11	2	3	65
Crockett	320	100	16	30	466
Davidson	8	0	0	0	8
Decatur	18	4	0	1	23
Dickson	0	0	0	0	0
Dyer	1,487	469	77	142	2,175
Fayette	267	74	11	21	373
Gibson	979	295	47	86	1,407
Giles	0	0	0	0	0
Hardeman	167	40	6	10	223
Hardin	74	22	3	6	105
Haywood	378	113	18	33	542
Henderson	134	32	4	7	177
Henry	150	37	5	9	201
Hickman	0	0	0	0	0
Houston	0	0	0	0	0
Humphreys	2	0	0	0	2
Lake	95	28	4	7	134
Lauderdale	713	223	37	66	1,039
Lawrence	0	0	0	0	0
Lewis	0	0	0	0	0
Madison	922	238	34	62	1,256
Maury	1	0	0	0	1
McNairy	70	16	2	4	92
Montgomery	1	0	0	0	1
Obion	423	126	20	35	604
Perry	1	0	0	0	1
Robertson	0	0	0	0	0
Shelby	23,870	7,339	1,171	2,225	34,605
Stewart	7	1	0	0	8
Tipton	1,116	350	57	104	1,627
Wayne	1	0	0	0	1
Weakley	510	152	25	45	732
Williamson	2	0	0	0	2

Table 98: Displaced/Shelter Seeking Population

Counties	Population	Displaced Population	Shelter Seeking Population
Benton	16,537	31	8
Carroll	29,475	1,475	395
Cheatham	35,912	0	0
Chester	15,540	475	122
Crockett	14,532	2,798	786
Davidson	569,891	2	1
Decatur	11,731	106	30
Dickson	43,156	0	0
Dyer	37,279	21,942	5,899
Fayette	28,806	2,776	730
Gibson	48,152	9,593	2,576
Giles	29,447	0	0
Hardeman	28,105	1,206	388
Hardin	25,578	1,370	412
Haywood	19,797	3,181	992
Henderson	25,522	2,063	536
Henry	31,115	1,334	387
Hickman	22,295	0	0
Houston	8,088	0	0
Humphreys	17,929	1	0
Lake	7,954	1,642	614
Lauderdale	27,101	13,243	3,975
Lawrence	39,926	0	0
Lewis	11,367	0	0
Madison	91,837	7,636	2,169
Maury	69,498	0	0
McNairy	24,653	522	145
Montgomery	134,768	0	0
Obion	32,450	7,798	2,071
Perry	7,631	0	0
Robertson	54,433	0	0
Shelby	897,472	161,189	45,466
Stewart	12,370	83	22
Tipton	51,271	18,244	4,390
Wayne	16,842	0	0
Weakley	34,895	4,197	1,179
Williamson	126,638	0	0

Table 99: Shelter Requirements

Counties	Total Space Required (sq. ft.)	Sleeping Space Required (sq. ft.)	Water Required Week 1 (gallons)	Ice Required Week 1 (lbs.)	MREs Required Week 1
Benton	3,840	480	280	448	112
Carroll	189,600	23,700	13,825	22,120	5,530
Cheatham	0	0	0	0	0
Chester	58,560	7,320	4,270	6,832	1,708
Crockett	377,280	47,160	27,510	44,016	11,004
Davidson	480	60	35	56	14
Decatur	14,400	1,800	1,050	1,680	420
Dickson	0	0	0	0	0
Dyer	2,831,520	353,940	206,465	330,344	82,586
Fayette	350,400	43,800	25,550	40,880	10,220
Gibson	1,236,480	154,560	90,160	144,256	36,064
Giles	0	0	0	0	0
Hardeman	186,240	23,280	13,580	21,728	5,432
Hardin	197,760	24,720	14,420	23,072	5,768
Haywood	476,160	59,520	34,720	55,552	13,888
Henderson	257,280	32,160	18,760	30,016	7,504
Henry	185,760	23,220	13,545	21,672	5,418
Hickman	0	0	0	0	0
Houston	0	0	0	0	0
Humphreys	0	0	0	0	0
Lake	294,720	36,840	21,490	34,384	8,596
Lauderdale	1,908,000	238,500	139,125	222,600	55,650
Lawrence	0	0	0	0	0
Lewis	0	0	0	0	0
Madison	1,041,120	130,140	75,915	121,464	30,366
Maury	0	0	0	0	0
McNairy	69,600	8,700	5,075	8,120	2,030
Montgomery	0	0	0	0	0
Obion	994,080	124,260	72,485	115,976	28,994
Perry	0	0	0	0	0
Robertson	0	0	0	0	0
Shelby	21,823,680	2,727,960	1,591,310	2,546,096	636,524
Stewart	10,560	1,320	770	1,232	308
Tipton	2,107,200	263,400	153,650	245,840	61,460
Wayne	0	0	0	0	0
Weakley	565,920	70,740	41,265	66,024	16,506
Williamson	0	0	0	0	0

Table 100: Debris Summary Report

Counties	Brick, Wood & Others (Thousand Tons)	Concrete & Steel (Thousand Tons)	Total (Thousand Tons)
Benton	4.78	1.72	6.50
Carroll	81.25	84.17	165.41
Cheatham	0.38	0.05	0.42
Chester	31.72	31.27	62.99
Crockett	92.23	120.11	212.33
Davidson	9.96	1.72	11.68
Decatur	12.69	8.60	21.29
Dickson	0.56	0.09	0.65
Dyer	502.53	557.54	1,060.07
Fayette	94.33	103.90	198.23
Gibson	312.88	346.09	658.97
Giles	0.40	0.06	0.46
Hardeman	58.71	56.19	114.90
Hardin	29.31	30.89	60.20
Haywood	116.97	163.20	280.17
Henderson	77.20	73.68	150.88
Henry	70.22	72.53	142.75
Hickman	0.26	0.04	0.30
Houston	0.69	0.15	0.83
Humphreys	3.23	1.08	4.31
Lake	28.54	35.58	64.11
Lauderdale	266.04	279.41	545.45
Lawrence	0.50	0.07	0.57
Lewis	0.14	0.02	0.16
Madison	310.18	361.05	671.23
Maury	0.92	0.15	1.07
McNairy	39.13	38.63	77.75
Montgomery	1.59	0.23	1.82
Obion	209.15	270.65	479.79
Perry	2.25	0.95	3.19
Robertson	0.64	0.10	0.74
Shelby	5,799.18	8,511.16	14,310.34
Stewart	7.54	4.54	12.08
Tipton	440.31	490.81	931.13
Wayne	0.76	0.27	1.04
Weakley	158.36	198.73	357.08
Williamson	1.83	0.27	2.11

Appendix VII: Guide for Impact Assessment Terminology

Abstract

This terminology guide was developed by the Mid-America Earthquake Center with the objective of providing a summary of definitions that aid in understanding the impact assessment report by non-experts. The information included in this document has been taken and adapted from the manuals of the Loss Assessment Program HAZUS-MH MR2.

The scope of this document includes the description of each component of inventory, definition of damage states and functionality after the occurrence of an earthquake. The four infrastructure systems included in this terminology guide are: General Building Stock, Essential Facilities, Transportation, and Utility Systems. Also, the definition of casualties is included in the second part of the guide.

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Part I

Part I

1. General Building Stock

1.1. Description of Model Building Types

Table 1 lists the 36 model building types employed in the earthquake loss assessment methodology.

Table 1. Model Building Types

No.	Label	Description	Height			
			Range		Typical	
			Name	Stories	Stories	Feet
1	W1	**Wood, Light Frame (≤ 5,000 sq. ft.)**		1 - 2	1	14
2	W2	**Wood, Commercial and Industrial (> 5,000 sq. ft.)**		All	2	24
3	S1L	**Steel Moment Frame**	Low-Rise	1 - 3	2	24
4	S1M		Mid-Rise	4 - 7	5	60
5	S1H		High-Rise	8+	13	156
6	S2L	**Steel Braced Frame**	Low-Rise	1 - 3	2	24
7	S2M		Mid-Rise	4 - 7	5	60
8	S2H		High-Rise	8+	13	156
9	S3	**Steel Light Frame**		All	1	15
10	S4L	**Steel Frame with Cast-in-Place Concrete Shear Walls**	Low-Rise	1 - 3	2	24
11	S4M		Mid-Rise	4 - 7	5	60
12	S4H		High-Rise	8+	13	156
13	S5L	**Steel Frame with Unreinforced Masonry Infill Walls**	Low-Rise	1 - 3	2	24
14	S5M		Mid-Rise	4 - 7	5	60
15	S5H		High-Rise	8+	13	156
16	C1L	**Concrete Moment Frame**	Low-Rise	1 – 3	2	20
17	C1M		Mid-Rise	4 - 7	5	50
18	C1H		High-Rise	8+	12	120
19	C2L	**Concrete Shear Walls**	Low-Rise	1 - 3	2	20
20	C2M		Mid-Rise	4 - 7	5	50
21	C2H		High-Rise	8+	12	120
22	C3L	**Concrete Frame with Unreinforced Masonry Infill Walls**	Low-Rise	1 - 3	2	20
23	C3M		Mid-Rise	4 - 7	5	50
24	C3H		High-Rise	8+	12	120
25	PC1	**Precast Concrete Tilt-Up Walls**		All	1	15
26	PC2L	**Precast Concrete Frames with Concrete Shear Walls**	Low-Rise	1 - 3	2	20
27	PC2M		Mid-Rise	4 - 7	5	50
28	PC2H		High-Rise	8+	12	120
29	RM1L	**Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms**	Low-Rise	1-3	2	20
30	RM1M		Mid-Rise	4+	5	50
31	RM2L	**Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms**	Low-Rise	1 - 3	2	20
32	RM2M		Mid-Rise	4 - 7	5	50
33	RM2H		High-Rise	8+	12	120
34	URML	**Unreinforced Masonry Bearing Walls**	Low-Rise	1 - 2	1	15
35	URMM		Mid-Rise	3+	3	35
36	MH	**Mobile Homes**		All	1	10

1.2. Description of Structural Systems

A general description of each of the 16 structural systems of model building types is given in the following sections.

Wood, Light Frame (W1)

These are typically single-family or small, multiple-family dwellings of not more than 5,000 square feet of floor area. The essential structural feature of these buildings is repetitive framing by wood rafters or joists on wood stud walls. Loads are light and spans are small. These buildings may have relatively heavy masonry chimneys and may be partially or fully covered with masonry veneer. Most of these buildings, especially the single-family residences, are not engineered but constructed in accordance with "conventional construction" provisions of building codes. Hence, they usually have the components of a lateral-force-resisting system even though it may be incomplete. Lateral loads are transferred by diaphragms to shear walls. The diaphragms are roof panels and floors that may be sheathed with sawn lumber, plywood or fiberboard sheathing. Shear walls are sheathed with boards, stucco, plaster, plywood, gypsum board, particle board, or fiberboard, or interior partition walls sheathed with plaster or gypsum board.

Wood, Greater than 5,000 Sq. Ft. (W2)

These buildings are typically commercial or industrial buildings, or multi-family residential buildings with a floor area greater than 5,000 square feet. These buildings include structural systems framed by beams or major horizontally spanning members over columns. These horizontal members may be glue-laminated (glu-lam) wood, solid-sawn wood beams, or wood trusses, or steel beams or trusses. Lateral loads usually are resisted by wood diaphragms and exterior walls sheathed with plywood, stucco, plaster, or other paneling. The walls may have diagonal rod bracing. Large openings for stores and garages often require post-and-beam framing. Lateral load resistance on those lines may be achieved with steel rigid frames (moment frames) or diagonal bracing.

Steel Moment Frame (S1)

These buildings have a frame of steel columns and beams. In some cases, the beam-column connections have very small moment resisting capacity but, in other cases, some of the beams and columns are fully developed as moment frames to resist lateral forces. Usually the structure is concealed on the outside by exterior nonstructural walls, which can be of almost any material (curtain walls, brick masonry, or precast concrete panels), and on the inside by ceilings and column furring. Diaphragms transfer lateral loads to moment-resisting frames. The diaphragms can be almost any material. The frames develop their stiffness by full or partial moment connections. The frames can be located almost anywhere in the building. Usually the columns have their strong directions oriented so that some columns act primarily in one direction while the others act in the other direction. Steel moment frame buildings are typically more flexible than shear wall

buildings. This low stiffness can result in large interstory drifts that may lead to relatively greater nonstructural damage.

Steel Braced Frame (S2)

These buildings are similar to steel moment frame buildings except that the vertical components of the lateral-force-resisting system are braced frames rather than moment frames.

Steel Light Frame (S3)

These buildings are pre-engineered and prefabricated with transverse rigid frames. The roof and walls consist of lightweight panels, usually corrugated metal. The frames are designed for maximum efficiency, often with tapered beam and column sections built up of light steel plates. The frames are built in segments and assembled in the field with bolted joints. Lateral loads in the transverse direction are resisted by the rigid frames with loads distributed to them by diaphragm elements, typically rod-braced steel roof framing bays. Tension rod bracing typically resists loads in the longitudinal direction.

Steel Frame with Cast-In-Place Concrete Shear Walls (S4)

The shear walls in these buildings are cast-in-place concrete and may be bearing walls. The steel frame is designed for vertical loads only. Diaphragms of almost any material transfer lateral loads to the shear walls. The steel frame may provide a secondary lateral-force-resisting system depending on the stiffness of the frame and the moment capacity of the beam-column connections. In modern "dual" systems, the steel moment frames are designed to work together with the concrete shear walls.

Steel Frame with Unreinforced Masonry Infill Walls (S5)

This is one of the older types of buildings. The infill walls usually are offset from the exterior frame members, wrap around them, and present a smooth masonry exterior with no indication of the frame. Solidly infilled masonry panels, when they fully engage the surrounding frame members (i.e. lie in the same plane), may provide stiffness and lateral load resistance to the structure.

Reinforced Concrete Moment Resisting Frames (C1)

These buildings are similar to steel moment frame buildings except that the frames are reinforced concrete. There are a large variety of frame systems. Some older concrete frames may be proportioned and detailed such that brittle failure of the frame members can occur in earthquakes leading to partial or full collapse of the buildings. Modern frames in zones of high seismicity are proportioned and detailed for ductile behavior and are likely to undergo large deformations during an earthquake without brittle failure of frame members and collapse.

Concrete Shear Walls (C2)

The vertical components of the lateral-force-resisting system in these buildings are concrete shear walls that are usually bearing walls. In older buildings, the walls often are quite extensive and the wall stresses are low but reinforcing is light. In newer buildings, the shear walls often are limited in extent, generating concerns about boundary members and overturning forces.

Concrete Frame Buildings with Unreinforced Masonry Infill Walls (C3)

These buildings are similar to steel frame buildings with unreinforced masonry infill walls except that the frame is of reinforced concrete. In these buildings, the shear strength of the columns, after cracking of the infill, may limit the semi-ductile behavior of the system.

Precast Concrete Tilt-Up Walls (PC1)

These buildings have a wood or metal deck roof diaphragm, which often is very large, that distributes lateral forces to precast concrete shear walls. The walls are thin but relatively heavy while the roofs are relatively light. Older or non-seismic-code buildings often have inadequate connections for anchorage of the walls to the roof for out-of-plane forces, and the panel connections often are brittle. Tilt-up buildings usually are one or two stories in height. Walls can have numerous openings for doors and windows of such size that the wall looks more like a frame than a shear wall.

Precast Concrete Frames with Concrete Shear Walls (PC2)

These buildings contain floor and roof diaphragms typically composed of precast concrete elements with or without cast-in-place concrete topping slabs. Precast concrete girders and columns support the diaphragms. The girders often bear on column corbels. Closure strips between precast floor elements and beam-column joints usually are cast-in-place concrete. Welded steel inserts often are used to interconnect precast elements. Precast or cast-in-place concrete shear walls resist lateral loads. For buildings with precast frames and concrete shear walls to perform well, the details used to connect the structural elements must have sufficient strength and displacement capacity; however, in some cases, the connection entails between the precast elements have negligible ductility.

Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms (RM1)

These buildings have perimeter bearing walls of reinforced brick or concrete-block masonry. These walls are the vertical elements in the lateral-force-resisting system. The floors and roofs are framed with wood joists and beams, either with plywood or braced sheathing, the latter either straight or diagonally sheathed, or with steel beams with metal deck with or without concrete fill. Interior wood posts or steel columns support wood floor framing; steel columns support steel beams.

Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms (RM2)

These buildings have bearing walls similar to those of reinforced masonry bearing wall structures with wood or metal deck diaphragms, but the roof and floors are composed of precast concrete elements such as planks or tee-beams and the precast roof and floor elements are supported on interior beams and columns of steel or concrete (cast-in-place or precast). The precast horizontal elements often have a cast-in-place topping.

Unreinforced Masonry Bearing Walls (URM)

These buildings include structural elements that vary depending on the building's age and, to a lesser extent, its geographic location. In buildings built before 1900, the majority of floor and roof construction consists of wood sheathing supported by wood framing. In large multistory buildings, the floors are cast-in-place concrete supported by the unreinforced masonry walls and/or steel or concrete interior framing. In unreinforced masonry constructed after 1950 (outside California) wood floors usually have plywood rather than board sheathing. In regions of lower seismicity, buildings of this type constructed more recently can include floor and roof framing that consists of metal deck and concrete fill supported by steel framing elements. The perimeter walls, and possibly some interior walls, are unreinforced masonry. The walls may or may not be anchored to the diaphragms. Ties between the walls and diaphragms are more common for the bearing walls than for walls that are parallel to the floor framing. Roof ties usually are less common and more erratically spaced than those at the floor levels. Interior partitions that interconnect the floors and roof can reduce diaphragm displacements.

Mobile Homes (MH)

These are prefabricated housing units that are trucked to the site and then placed on isolated piers, jack stands, or masonry block foundations (usually without any positive anchorage). Floors and roofs of mobile homes usually are constructed with plywood and outside surfaces are covered with sheet metal.

1.3. Description of Nonstructural Components

Nonstructural components include a large variety of different architectural, mechanical and electrical components. Contents of the buildings are treated as a separate category. Nonstructural components are grouped as either "drift-sensitive" or "acceleration-sensitive" components, in order to assess their damage due to an earthquake. Damage to drift-sensitive nonstructural components is primarily a function of interstory drift; damage to acceleration-sensitive nonstructural components and building contents is primarily a function of floor acceleration. Table 2 lists typical nonstructural components and building contents, and identifies each item as drift-sensitive or acceleration sensitive.

Anchorage/bracing of nonstructural components improves earthquake performance of most components although routine or typical anchorage/bracing provides only limited

damage protection. It is assumed that typical nonstructural components and building contents have limited anchorage/bracing. Nonstructural damage evaluation is dependent upon the response and performance of structural components, as well as being influenced by characteristics of nonstructural components themselves.

Type	Item	Drift-Sensitive*	Acceleration-Sensitive*
Architectural	Nonbearing Walls/Partitions	•	◦
	Cantilever Elements and Parapets		•
	Exterior Wall Panels	•	◦
	Veneer and Finishes	•	◦
	Penthouses	•	
	Racks and Cabinets		•
	Access Floors		•
	Appendages and Ornaments		•
Mechanical and Electrical	General Mechanical (boilers, etc.)		•
	Manufacturing and Process Machinery		•
	Piping Systems	◦	•
	Storage Tanks and Spheres		•
	HVAC Systems (chillers, ductwork, etc.)	◦	•
	Elevators	◦	•
	Trussed Towers		•
	General Electrical (switchgear, ducts, etc.)	◦	•
	Lighting Fixtures		•
Contents	File Cabinets, Bookcases, etc.		•
	Office Equipment and Furnishings		•
	Computer/Communication Equipment		•
	Nonpermanent Manufacturing Equipment		•
	Manufacturing/Storage Inventory		•
	Art and other Valuable Objects		•

* Solid dots indicate primary cause of damage, open dots indicate secondary cause of damage

Table 2. List of Typical Nonstructural Components and Contents of Buildings

1.4. Description of Building Damage States

The results of damage estimation methods described in this chapter (i.e., damage predictions for model building types for a given level of ground shaking) are used in other modules of the methodology to estimate: (1) casualties due to structural damage, including fatalities, (2) monetary losses due to building damage (i.e. cost of repairing or replacing damaged buildings and their contents); (3) monetary losses resulting from building damage and closure (e.g., losses due to business interruption); (4) social impacts (e.g., loss of shelter); and, (5) other economic and social impacts.

The building damage predictions may also be used to study expected damage patterns in a given region for different scenario earthquakes (e.g., to identify the most vulnerable building types, or the areas expected to have the most damaged buildings). In order to meet the needs of such broad purposes, damage predictions must allow the user to glean the nature and extent of the physical damage to a building type from the damage

prediction output so that life-safety, societal functional and monetary losses which result from the damage can be estimated. Building damage can best be described in terms of its components (beams, columns, walls, ceilings, piping, HVAC equipment, etc.). For example, such component damage descriptions as “shear walls are cracked”, “ceiling tiles fell”, “diagonal bracing buckled”, “wall panels fell out”, etc. used together with such terms as “some” and “most” would be sufficient to describe the nature and extent of overall building damage.

Damage to nonstructural components of buildings (i.e., architectural components, such as partition walls and ceilings, and building mechanical/electrical systems) primarily affects monetary and societal functional losses and generates numerous casualties of mostly light-to moderate severity. Hazard mitigation measures are different for nonstructural and structural building components (i.e., the gravity and lateral-load-resisting systems) as well. Hence, it is desirable to separately estimate structural and nonstructural damage.

Building damage varies from “none” to “complete” as a continuous function of building deformations (building response). Wall cracks may vary from invisible or “hairline cracks” to cracks of several inches wide. Generalized “ranges” of damage are used by the Methodology to describe structural and nonstructural damage, since it is not practical to describe building damage as a continuous function.

The Methodology predicts a structural and nonstructural damage state in terms of one of four ranges of damage or “damage states”: Slight, Moderate, Extensive, and Complete. For example, the Slight damage state extends from the threshold of Slight damage up to the threshold of Moderate damage. General descriptions of these damage states are provided for all model building types with reference to observable damage incurred by structural (Section 5.3.1) and nonstructural building components (Section 5.3.2). Damage predictions resulting from this physical damage estimation method are then expressed in terms of the probability of a building being in any of these four damage states.

1.4.1 Structural Damage

Descriptions for Slight, Moderate, Extensive, and Complete structural damage states for the 16 basic model building types are provided below. For estimating casualties, the descriptions of Complete damage include the fraction of the total floor area of each model building type that is likely to collapse. Collapse fractions are based on judgment and limited earthquake data considering the material and construction of different model building types.

It is noted that in some cases the structural damage is not directly observable because the structural elements are inaccessible or not visible due to architectural finishes or fireproofing. Hence, these structural damage states are described, when necessary, with reference to certain effects on nonstructural elements that may be indicative of the structural damage state of concern. Small cracks are assumed, throughout this section, to be visible cracks with a maximum width of less than 1/8”. Cracks wider than 1/8” are referred to as “large” cracks.

<u>Wood, Light Frame (W1):</u>

Slight Structural Damage: Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.

Moderate Structural Damage: Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.

Extensive Structural Damage: Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of “room-over-garage” or other “soft-story” configurations; small foundations cracks.

Complete Structural Damage: Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks. Approximately 3% of the total area of W1 buildings with Complete damage is expected to be collapsed.

<u>Wood, Commercial and Industrial (W2):</u>

Slight Structural Damage: Small cracks at corners of door and window openings and wall-ceiling intersections; small cracks on stucco and plaster walls. Some slippage may be observed at bolted connections.

Moderate Structural Damage: Larger cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by cracks in stucco and gypsum wall panels; minor slack (less than 1/8” extension) in diagonal rod bracing requiring re-tightening; minor lateral set at store fronts and other large openings; small cracks or wood splitting may be observed at bolted connections.

Extensive Structural Damage: Large diagonal cracks across shear wall panels; large slack in diagonal rod braces and/or broken braces; permanent lateral movement of floors and roof; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of “soft-story” configurations; bolt slippage and wood splitting at bolted connections.

Complete Structural Damage: Structure may have large permanent lateral displacement, may collapse or be in imminent danger of collapse due to failed shear walls, broken brace rods or failed framing connections; it may fall its foundations; large cracks in the

foundations. Approximately 3% of the total area of W2 buildings with Complete damage is expected to be collapsed.

Steel Moment Frame (S1):

Slight Structural Damage: Minor deformations in connections or hairline cracks in few welds.

Moderate Structural Damage: Some steel members have yielded exhibiting observable permanent rotations at connections; few welded connections may exhibit major cracks through welds or few bolted connections may exhibit broken bolts or enlarged bolt holes.

Extensive Structural Damage: Most steel members have exceeded their yield capacity, resulting in significant permanent lateral deformation of the structure. Some of the structural members or connections may have exceeded their ultimate capacity exhibited by major permanent member rotations at connections, buckled flanges and failed connections. Partial collapse of portions of structure is possible due to failed critical elements and/or connections.

Complete Structural Damage: Significant portion of the structural elements have exceeded their ultimate capacities or some critical structural elements or connections have failed resulting in dangerous permanent lateral displacement, partial collapse or collapse of the building. Approximately 8 % (low-rise), 5% (mid-rise) or 3% (high-rise) of the total area of S1 buildings with Complete damage is expected to be collapsed.

Steel Braced Frame (S2):

Slight Structural Damage: Few steel braces have yielded which may be indicated by minor stretching and/or buckling of slender brace members; minor cracks in welded connections; minor deformations in bolted brace connections.

Moderate Structural Damage: Some steel braces have yielded exhibiting observable stretching and/or buckling of braces; few braces, other members or connections have indications of reaching their ultimate capacity exhibited by buckled braces, cracked welds, or failed bolted connections.

Extensive Structural Damage: Most steel brace and other members have exceeded their yield capacity, resulting in significant permanent lateral deformation of the structure. Some structural members or connections have exceeded their ultimate capacity exhibited by buckled or broken braces, flange buckling, broken welds, or failed bolted connections. Anchor bolts at columns may be stretched. Partial collapse of portions of structure is possible due to failure of critical elements or connections.

Complete Structural Damage: Most the structural elements have reached their ultimate capacities or some critical members or connections have failed resulting in dangerous permanent lateral deflection, partial collapse or collapse of the building. Approximately

8% (low-rise), 5% (mid-rise) or 3% (high-rise) of the total area of S2 buildings with Complete damage is expected to be collapsed.

<u>Steel Light Frame (S3):</u>

These structures are mostly single story structures combining rod-braced frames in one direction and moment frames in the other. Due to repetitive nature of the structural systems, the type of damage to structural members is expected to be rather uniform throughout the structure.

Slight Structural Damage: Few steel rod braces have yielded which may be indicated by minor sagging of rod braces. Minor cracking at welded connections or minor deformations at bolted connections of moment frames may be observed.

Moderate Structural Damage: Most steel braces have yielded exhibiting observable significantly sagging rod braces; few brace connections may be broken. Some weld cracking may be observed in the moment frame connections.

Extensive Structural Damage: Significant permanent lateral deformation of the structure due to broken brace rods, stretched anchor bolts and permanent deformations at moment frame members. Some screw or welded attachments of roof and wall siding to steel framing may be broken. Some purlin and girt connections may be broken.

Complete Structural Damage: Structure is collapsed or in imminent danger of collapse due to broken rod bracing, failed anchor bolts or failed structural members or connections. Approximately 3% of the total area of S3 buildings with Complete damage is expected to be collapsed.

<u>Steel Frame with Cast-In-Place Concrete Shear Walls (S4):</u>

This is a "composite" structural system where primary lateral-force-resisting system is the concrete shear walls. Hence, Slight, Moderate and Extensive damage states are likely to be determined by the shear walls while the collapse damage state would be determined by the failure of the structural frame.

Slight Structural Damage: Diagonal hairline cracks on most concrete shear wall surfaces; minor concrete spalling at few locations.

Moderate Structural Damage: Most shear wall surfaces exhibit diagonal cracks; some of the shear walls have exceeded their yield capacities exhibited by larger diagonal cracks and concrete spalling at wall ends.

Extensive Structural Damage: Most concrete shear walls have exceeded their yield capacities; few walls have reached or exceeded their ultimate capacity exhibited by large through-the wall diagonal cracks, extensive spalling around the cracks and visibly

buckled wall reinforcement. Partial collapse may occur due to failed connections of steel framing to concrete walls. Some damage may be observed in steel frame connections.

Complete Structural Damage: Structure may be in danger of collapse or collapse due to total failure of shear walls and loss of stability of the steel frames. Approximately 8% (low-rise), 5% (mid-rise) or 3% (high-rise) of the total area of S4 buildings with Complete damage is expected to be collapsed.

<u>Steel Frame with Unreinforced Masonry Infill Walls (S5):</u>

This is a "composite" structural system where the initial lateral resistance is provided by the infill walls. Upon cracking of the infills, further lateral resistance is provided by the steel frames "braced" by the infill walls acting as diagonal compression struts. Collapse of the structure results when the infill walls disintegrate (due to compression failure of the masonry "struts") and the steel frame loses its stability.

Slight Structural Damage: Diagonal (sometimes horizontal) hairline cracks on most infill walls; cracks at frame-infill interfaces.

Moderate Structural Damage: Most infill wall surfaces exhibit larger diagonal or horizontal cracks; some walls exhibit crushing of brick around beam-column connections.

Extensive Structural Damage: Most infill walls exhibit large cracks; some bricks may be dislodged and fall; some infill walls may bulge out-of-plane; few walls may fall off partially or fully; some steel frame connections may have failed. Structure may exhibit permanent lateral deformation or partial collapse due to failure of some critical members.

Complete Structural Damage: Structure is collapsed or in danger of imminent collapse due to total failure of many infill walls and loss of stability of the steel frames. . Approximately 8% (low-rise), 5% (mid-rise) or 3% (high-rise) of the total area of S5 buildings with Complete damage is expected to be collapsed.

<u>Reinforced Concrete Moment Resisting Frames (C1):</u>

Slight Structural Damage: Flexural or shear type hairline cracks in some beams and columns near joints or within joints.

Moderate Structural Damage: Most beams and columns exhibit hairline cracks. In ductile frames some of the frame elements have reached yield capacity indicated by larger flexural cracks and some concrete spalling. Nonductile frames may exhibit larger shear cracks and spalling.

Extensive Structural Damage: Some of the frame elements have reached their ultimate capacity indicated in ductile frames by large flexural cracks, spalled concrete and buckled main reinforcement; nonductile frame elements may have suffered shear failures or bond

failures at reinforcement splices, or broken ties or buckled main reinforcement in columns which may result in partial collapse.

Complete Structural Damage: Structure is collapsed or in imminent danger of collapse due to brittle failure of nonductile frame elements or loss of frame stability. Approximately 13% (low-rise), 10% (mid-rise) or 5% (high-rise) of the total area of C1 buildings with Complete damage is expected to be collapsed.

Concrete Shear Walls (C2):

Slight Structural Damage: Diagonal hairline cracks on most concrete shear wall surfaces; minor concrete spalling at few locations.

Moderate Structural Damage: Most shear wall surfaces exhibit diagonal cracks; some shear walls have exceeded yield capacity indicated by larger diagonal cracks and concrete spalling at wall ends.

Extensive Structural Damage: Most concrete shear walls have exceeded their yield capacities; some walls have exceeded their ultimate capacities indicated by large, through-the-wall diagonal cracks, extensive spalling around the cracks and visibly buckled wall reinforcement or rotation of narrow walls with inadequate foundations. Partial collapse may occur due to failure of nonductile columns not designed to resist lateral loads.

Complete Structural Damage: Structure has collapsed or is in imminent danger of collapse due to failure of most of the shear walls and failure of some critical beams or columns. Approximately 13% (low-rise), 10% (mid-rise) or 5% (high-rise) of the total area of C2 buildings with Complete damage is expected to be collapsed.

Concrete Frame Buildings with Unreinforced Masonry Infill Walls (C3):

This is a “composite” structural system where the initial lateral resistance is provided by the infill walls. Upon cracking of the infills, further lateral resistance is provided by the concrete frame “braced” by the infill acting as diagonal compression struts. Collapse of the structure results when the infill walls disintegrate (due to compression failure of the masonry “struts”) and the frame loses stability, or when the concrete columns suffer shear failures due to reduced effective height and the high shear forces imposed on them by the masonry compression struts.

Slight Structural Damage: Diagonal (sometimes horizontal) hairline cracks on most infill walls; cracks at frame-infill interfaces.

Moderate Structural Damage: Most infill wall surfaces exhibit larger diagonal or horizontal cracks; some walls exhibit crushing of brick around beam-column connections. Diagonal shear cracks may be observed in concrete beams or columns.

Extensive Structural Damage: Most infill walls exhibit large cracks; some bricks may dislodge and fall; some infill walls may bulge out-of-plane; few walls may fall partially or fully; few concrete columns or beams may fail in shear resulting in partial collapse. Structure may exhibit permanent lateral deformation.

Complete Structural Damage: Structure has collapsed or is in imminent danger of collapse due to a combination of total failure of the infill walls and nonductile failure of the concrete beams and columns. Approximately 15% (low-rise), 13% (mid-rise) or 5% (high-rise) of the total area of C3 buildings with Complete damage is expected to be collapsed.

Precast Concrete Tilt-Up Walls (PC1):

Slight Structural Damage: Diagonal hairline cracks on concrete shear wall surfaces; larger cracks around door and window openings in walls with large proportion of openings; minor concrete spalling at few locations; minor separation of walls from the floor and roof diaphragms; hairline cracks around metal connectors between wall panels and at connections of beams to walls.

Moderate Structural Damage: Most wall surfaces exhibit diagonal cracks; larger cracks in walls with door or window openings; few shear walls have exceeded their yield capacities indicated by larger diagonal cracks and concrete spalling. Cracks may appear at top of walls near panel intersections indicating "chord" yielding. Some walls may have visibly pulled away from the roof. Some welded panel connections may have been broken, indicated by spalled concrete around connections. Some spalling may be observed at the connections of beams to walls.

Extensive Structural Damage: In buildings with relatively large area of wall openings most concrete shear walls have exceeded their yield capacities and some have exceeded their ultimate capacities indicated by large, through-the-wall diagonal cracks, extensive spalling around the cracks and visibly buckled wall reinforcement. The plywood diaphragms may exhibit cracking and separation along plywood joints. Partial collapse of the roof may result from the failure of the wall-to-diaphragm anchorages sometimes with falling of wall panels.

Complete Structural Damage: Structure is collapsed or is in imminent danger of collapse due to failure of the wall-to-roof anchorages, splitting of ledgers, or failure of plywood-to-ledger nailing; failure of beams connections at walls; failure of roof or floor diaphragms; or, failure of the wall panels. Approximately 15% of the total area of PC1 buildings with Complete damage is expected to be collapsed.

Precast Concrete Frames with Concrete Shear Walls (PC2):

Slight Structural Damage: Diagonal hairline cracks on most shear wall surfaces; minor concrete spalling at few connections of precast members.

Moderate Structural Damage: Most shear wall surfaces exhibit diagonal cracks; some shear walls have exceeded their yield capacities indicated by larger cracks and concrete spalling at wall ends; observable distress or movement at connections of precast frame connections, some failures at metal inserts and welded connections.

Extensive Structural Damage: Most concrete shear walls have exceeded their yield capacities; some walls may have reached their ultimate capacities indicated by large, through-the wall diagonal cracks, extensive spalling around the cracks and visibly buckled wall reinforcement. Some critical precast frame connections may have failed resulting partial collapse.

Complete Structural Damage: Structure has collapsed or is in imminent danger of collapse due to failure of the shear walls and/or failures at precast frame connections. Approximately 15% (low-rise), 13% (mid-rise) or 10% (high-rise) of the total area of PC2 buildings with Complete damage is expected to be collapsed.

<u>Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms (RM1):</u>

Slight Structural Damage: Diagonal hairline cracks on masonry wall surfaces; larger cracks around door and window openings in walls with large proportion of openings; minor separation of walls from the floor and roof diaphragms.

Moderate Structural Damage: Most wall surfaces exhibit diagonal cracks; some of the shear walls have exceeded their yield capacities indicated by larger diagonal cracks. Some walls may have visibly pulled away from the roof.

Extensive Structural Damage: In buildings with relatively large area of wall openings most shear walls have exceeded their yield capacities and some of the walls have exceeded their ultimate capacities indicated by large, through-the-wall diagonal cracks and visibly buckled wall reinforcement. The plywood diaphragms may exhibit cracking and separation along plywood joints. Partial collapse of the roof may result from failure of the wall-to-diaphragm anchorages or the connections of beams to walls.

Complete Structural Damage: Structure has collapsed or is in imminent danger of collapse due to failure of the wall anchorages or due to failure of the wall panels. Approximately 13% (low-rise) or 10% (mid-rise) of the total area of RM1 buildings with Complete damage is expected to be collapsed.

<u>Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms (RM2):</u>

Slight Structural Damage: Diagonal hairline cracks on masonry wall surfaces; larger cracks around door and window openings in walls with large proportion of openings.

Moderate Structural Damage: Most wall surfaces exhibit diagonal cracks; some of the shear walls have exceeded their yield capacities indicated by larger cracks.

Extensive Structural Damage: In buildings with relatively large area of wall openings most shear walls have exceeded their yield capacities and some of the walls have exceeded their ultimate capacities exhibited by large, through-the wall diagonal cracks and visibly buckled wall reinforcement. The diaphragms may also exhibit cracking.

Complete Structural Damage: Structure is collapsed or is in imminent danger of collapse due to failure of the walls. Approximately 13% (low-rise), 10% (mid-rise) or 5% (high-rise) of the total area of RM2 buildings with Complete damage is expected to be collapsed.

<u>**Unreinforced Masonry Bearing Walls (URM):**</u>

Slight Structural Damage: Diagonal, stair-step hairline cracks on masonry wall surfaces; larger cracks around door and window openings in walls with large proportion of openings; movements of lintels; cracks at the base of parapets.

Moderate Structural Damage: Most wall surfaces exhibit diagonal cracks; some of the walls exhibit larger diagonal cracks; masonry walls may have visible separation from diaphragms; significant cracking of parapets; some masonry may fall from walls or parapets.

Extensive Structural Damage: In buildings with relatively large area of wall openings most walls have suffered extensive cracking. Some parapets and gable end walls have fallen. Beams or trusses may have moved relative to their supports.

Complete Structural Damage: Structure has collapsed or is in imminent danger of collapse due to in-plane or out-of-plane failure of the walls. Approximately 15% of the total area of URM buildings with Complete damage is expected to be collapsed.

<u>**Mobile Homes (MH):**</u>

Slight Structural Damage: Damage to some porches, stairs or other attached components.

Moderate Structural Damage: Major movement of the mobile home over its supports resulting in some damage to metal siding and stairs and requiring resetting of the mobile home on its supports.

Extensive Structural Damage: Mobile home has fallen partially off its supports, often severing utility lines.

Complete Structural Damage: Mobile home has totally fallen off its supports; usually severing utility lines, with steep jack stands penetrating through the floor. Approximately 3% of the total area of MH buildings with Complete damage is expected to be collapsed.

1.4.2 Nonstructural Damage

Four damage states are used to describe nonstructural damage: Slight, Moderate, Extensive and Complete nonstructural damage. Nonstructural damage is considered to be independent of the structural model building type (i.e. partitions, ceilings, cladding, etc. are assumed to incur the same damage when subjected to the same interstory drift or floor acceleration whether they are in a steel frame building or in a concrete shear wall building), consequently, building-specific damage state descriptions are not meaningful. Instead, general descriptions of nonstructural damage states are provided for common nonstructural systems.

Damage to drift-sensitive nonstructural components is primarily a function of interstory drift (e.g. full-height drywall partitions) while for acceleration-sensitive components (e.g. mechanical equipment) damage is a function of the floor acceleration. Developing fragility curves for each possible nonstructural component is not practicable for the purposes of regional loss estimation and there is insufficient data to develop such fragility curves. Hence, in this methodology nonstructural building components are grouped into drift-sensitive and acceleration-sensitive component groups, and the damage functions estimated for each group are assumed to be "typical" of it sub-components. Note, however, that damage depends on the anchorage/bracing provided to the nonstructural components. Damageability characteristics of each group are described by a set of fragility curves (see Subsection 5.4.3.3).

The type of nonstructural components in a given building is a function of the building occupancy-use classification. For example, single-family residences would not have curtain wall panels, suspended ceilings, elevators, etc. while these items would be found in an office building. Hence, the relative values of nonstructural components in relation to the overall building replacement value vary with type of occupancy. In Chapter 15, estimates of replacement cost breakdown between structural building components for different occupancy/use related classifications are provided; further breakdowns are provided by drift- and acceleration-sensitive nonstructural components.

In the following, general descriptions of the four nonstructural damage states are described for common nonstructural building components:

<u>Partitions Walls</u>

Slight Nonstructural Damage: A few cracks are observed at intersections of walls and ceilings and at corners of door openings.

Moderate Nonstructural Damage: Larger and more extensive cracks requiring repair and repainting; some partitions may require replacement of gypsum board or other finishes.

Extensive Nonstructural Damage: Most of the partitions are cracked and a significant portion may require replacement of finishes; some door frames in the partitions are also damaged and require re-setting.

Complete Nonstructural Damage: Most partition finish materials and framing may have to be removed and replaced; damaged studs repaired, and walls refinished. Most door frames may also have to be repaired and replaced.

Suspended Ceilings

Slight Nonstructural Damage: A few ceiling tiles have moved or fallen down.

Moderate Nonstructural Damage: Falling of tiles is more extensive; in addition the ceiling support framing (T-bars) has disconnected and/or buckled at few locations; lenses have fallen off of some light fixtures and a few fixtures have fallen; localized repairs are necessary.

Extensive Nonstructural Damage: The ceiling system exhibits extensive buckling, disconnected t-bars and falling ceiling tiles; ceiling partially collapses at few locations and some light fixtures fall; repair typically involves removal of most or all ceiling tiles.

Complete Nonstructural Damage: The ceiling system is buckled throughout and/or fallen and requires complete replacement; many light fixtures fall.

Exterior Wall Panels

Slight Nonstructural Damage: Slight movement of the panels, requiring realignment.

Moderate Nonstructural Damage: The movements are more extensive; connections of panels to structural frame are damaged requiring further inspection and repairs; some window frames may need realignment.

Extensive Nonstructural Damage: Most of the panels are cracked or otherwise damaged and misaligned, and most panel connections to the structural frame are damaged requiring thorough review and repairs; few panels fall or are in imminent danger of falling; some window panes are broken and some pieces of glass have fallen.

Complete Nonstructural Damage: Most panels are severely damaged, most connections are broken or severely damaged, some panels have fallen and most are in imminent danger of falling; extensive glass breakage and falling.

Electrical-Mechanical Equipment, Piping, Ducts

Slight Nonstructural Damage: The most vulnerable equipment (e.g. unanchored or on spring isolators) moves and damages attached piping or ducts.

Moderate Nonstructural Damage: Movements are larger and damage is more extensive; piping leaks at few locations; elevator machinery and rails may require realignment.

Extensive Nonstructural Damage: Equipment on spring isolators topples and falls; other unanchored equipment slides or falls breaking connections to piping and ducts; leaks develop at many locations; anchored equipment indicate stretched bolts or strain at anchorages.

Complete Nonstructural Damage: Equipment is damaged by sliding, overturning or failure of their supports and is not operable; piping is leaking at many locations; some pipe and duct supports have failed causing pipes and ducts to fall or hang down; elevator rails are buckled or have broken supports and/or counterweights have derailed.

2. Essential Facilities

2.1. Description of Essential Facilities

Essential facilities are those facilities that provide services to the community and should be functional after an earthquake. Essential facilities include hospitals, police stations, fire stations and schools. The damage state probabilities for essential facilities are determined on a site-specific basis (i.e., the ground motion parameters are computed at the location of the facility).

2.2. Description of Building Damage States for Essential Facilities

Building damage states for structural and nonstructural components of essential facilities are the same as those described in Chapter 1 for general building stock.

3. Transportation Systems

Transportation systems include the following seven systems: Highways, Railways, Light Rails, Bus Facilities, Ports, Ferry and Airports

3.1. Highways Transportation System:

This system consists of roadways, bridges and tunnels.

3.1.1. Description of Highway Components

In this section, a brief description of each highway component is given.

Roadways

Roadways are classified as major roads and urban roads. Major roads include interstate and state highways and other roads with four lanes or more. Parkways are also classified as major roads. Urban roads include intercity roads and other roads with two lanes.

Bridges

Bridges are classified based on the following structural characteristics:

- Seismic Design
- Number of spans: single vs. multiple span bridges
- Structure type: concrete, steel, others
- Pier type: multiple column bents, single column bents and pier walls
- Abutment type and bearing type: monolithic vs. non-monolithic; high rocker bearings, low steel bearings and neoprene rubber bearings
- Span continuity: continuous, discontinuous (in-span hinges), and simply supported.

Tunnels

Tunnels are classified as bored/drilled or cut & cover.

3.1.2. Definition of Damage States of Highway Components

A total of five damage states are defined for highway system components. These are none, slight/minor, moderate, extensive and complete.

Slight/Minor Damage (DS2)

- For **roadways**, DS2 is defined by slight settlement (few inches) or offset of the ground.

- For **bridges**, DS2 is defined by minor cracking and spalling to the abutment, cracks in shear keys at abutments, minor spalling and cracks at hinges, minor spalling at the column (damage requires no more than cosmetic repair) or minor cracking to the deck.

- For **tunnels**, DS2 is defined by minor cracking of the tunnel liner (damage requires no more than cosmetic repair) and some rock falling, or by slight settlement of the ground at a tunnel portal.

Moderate Damage (DS3)

- For **roadways**, DS3 is defined by moderate settlement (several inches) or offset of the ground.

- For **bridges**, DS3 is defined by any column experiencing moderate (shear cracks) cracking and spalling (column structurally still sound), moderate movement of the abutment (<2"), extensive cracking and spalling of shear keys, any connection having cracked shear keys or bent bolts, keeper bar failure without unseating, rocker bearing failure or moderate settlement of the approach.

- For **tunnels**, DS3 is defined by moderate cracking of the tunnel liner and rock falling.

Extensive Damage (DS4)

- For **roadways**, DS4 is defined by major settlement of the ground (few feet).

- For **bridges**, DS4 is defined by any column degrading without collapse – shear failure – (column structurally unsafe), significant residual movement at connections, or major settlement approach, vertical offset of the abutment, differential settlement at connections, shear key failure at abutments.

- For **tunnels**, DS4 is characterized by major ground settlement at a tunnel portal and extensive cracking of the tunnel liner.

Complete Damage (DS5)

- For **roadways**, DS5 is defined by major settlement of the ground (i.e., same as DS4).

- For **bridges**, DS5 is defined by any column collapsing and connection losing all bearing support, which may lead to imminent deck collapse, tilting of substructure due to foundation failure.

- For **tunnels**, DS5 is characterized by major cracking of the tunnel liner, which may include possible collapse.

3.1.3. Functionality of Highway Components

Component functionality is described by the probability of damage state (immediately following the earthquake) and by the associated fraction or percentage of the component that is expected to be functional after a specified period of time. For example, a roadway link might be found to have a 0.50 probability of extensive damage and on this basis would have a 0.50 probability that the road would be: (1) closed immediately, (2) partially open after a 3-day restoration period and (3) fully open after a 1-month restoration period.

3.2. Railway Transportation System:

This system consists of tracks/roadbeds, bridges, tunnels, urban stations, maintenance facilities, fuel facilities, and dispatch facilities.

3.2.1. Description of Railway System Components

A railway system consists of four components: tracks/roadbeds, bridges, tunnels, and facilities.

Tracks/Roadbeds

Tracks/roadbeds refers to the assembly of rails, ties, and fastenings, and the ground on which they rest. Only one classification is adopted for these components. This classification is analogous to that of urban roads in highway systems.

Bridges

Railway bridges are classified similar to highway steel and concrete bridges.

Tunnels

Railway tunnels follow the same classification as highway tunnels. That is, they are classified either as bored/drilled tunnels or cut & cover tunnels.

Railway System Facilities

Railway system facilities include urban and suburban stations, maintenance facilities, fuel facilities, and dispatch facilities.

Urban and Suburban stations are generally key connecting hubs that are important for system functionality. In western US, these buildings are mostly made of reinforced concrete shear walls or moment resisting steel frames, while in the eastern US, the small stations are mostly wood and the large ones are mostly masonry or braced steel frames.

Maintenance facilities are housed in large structures that are not usually critical for system functionality as maintenance activities can be delayed or performed elsewhere. These building structures are often made of steel braced frames.

Fuel facilities include buildings, tanks (anchored, unanchored, or buried), backup power systems (if available, anchored or unanchored diesel generators), pumps, and other equipment (anchored or unanchored). It should be mentioned that anchored equipment in general refers to equipment designed with special seismic tiedowns or tiebacks, while unanchored equipment refers to equipment designed with no special considerations other than the manufacturer's normal requirements. While some vibrating components, such as

pumps, are bolted down regardless of concern for earthquakes, as used here “anchored” means all components have been engineered to meet seismic criteria which may include bracing (e.g., pipe or stack bracing) or flexibility requirements (e.g., flexible connections across separation joints) as well as anchorage. These definitions of anchored and unanchored apply to all lifeline components. The fuel facility functionality is determined with a fault tree analysis considering redundancies and subcomponent behavior. Note that generic building damage functions are used in this fault tree analysis for developing the overall fragility curve of fuel facilities. Above ground tanks are typically made of steel with roofs also made of steel. Buried tanks are typically concrete wall construction with concrete roofs. In total, five types of fuel facilities are considered. These are: fuel facilities with or without anchored equipment and with or without backup power (all combinations), and fuel facilities with buried tanks.

Dispatch facilities consist of buildings, backup power supplies (if available, anchored or unanchored diesel generators), and electrical equipment (anchored or unanchored). Generic reinforced concrete building with shear walls damage functions, are used in this fault tree analysis for developing the overall fragility curves for dispatch facilities. In total, four types of dispatch facilities are considered. These are dispatch facilities with or without anchored equipment and with or without backup power (all combinations).

3.2.2. Definitions of Damage States of Railway System Components

A total of five damage states are defined for railway system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight/Minor Damage (DS2)

- For **tracks and roadbeds**, DS2 is defined by minor (localized) derailment due to slight differential settlement of embankment or offset of the ground.

- For **railway bridges**, DS2 is defined similar to highway bridges.

- For **railway tunnels**, DS2 is defined similar to highway tunnels.

- For railway system facilities:

- For **urban stations** and **maintenance facilities**, DS2 is defined by slight building damage (check chapter 1 for full description of potential damage).

- For **fuel facilities with anchored equipment**, DS2 is defined by slight damage to pump building, minor damage to anchor of tanks, or loss of off-site power (check electric power systems for more on this) for a very short period and minor damage to backup power (i.e. to diesel generators, if available).

- For **fuel facilities with unanchored equipment**, DS2 is defined by elephant foot buckling of tanks with no leakage or loss of contents, slight damage to pump building, or loss of commercial power for a very short period and minor damage to backup power (i.e. to diesel generators, if available).

- For **fuel facilities with buried tanks** (PGD related damage), DS2 is defined by minor uplift (few inches) of the buried tanks or minor cracking of concrete walls.

- For **dispatch facilities with anchored equipment**, DS2 is defined by minor anchor damage, slight damage to building, or loss of commercial power for a very short period and minor damage to backup power (i.e. diesel generators, if available).

- For **dispatch facilities with unanchored equipment**, DS2 is defined by loss of off-site power for a very short period and minor damage to backup power (i.e. to diesel generators, if available), or slight damage to building.

<u>Moderate Damage (DS3)</u>

- For **railway tracks** and **roadbeds**, DS3 is defined by considerable derailment due to differential settlement or offset of the ground. Rail repair is required.

- For **railway bridges**, DS3 is defined as for highway bridges.

- For **railway tunnels**, DS3 is defined as for highway tunnels.

- For railway system facilities:

- For **urban stations** and **maintenance facilities**, DS3 is defined by moderate building damage (check Chapter 1 for description of potential damage).

- For **fuel facilities with anchored equipment**, DS3 is defined by elephant foot buckling of tanks with no leakage or loss of contents, considerable damage to equipment, moderate damage to pump building, or loss of commercial power for few days and malfunction of backup power (i.e., diesel generators, if available).

- For **fuel facilities with unanchored equipment**, DS3 is defined by elephant foot buckling of tanks with partial loss of contents, moderate damage to pump building, loss of commercial power for few days and malfunction of backup power (i.e., diesel generators, if available).

- For **fuel facilities with buried tanks**, DS3 is defined by damage to roof supporting columns, and considerable cracking of walls.

- For **dispatch facilities with anchored equipment**, DS3 is defined by considerable anchor damage, moderate damage to building, or loss of commercial power for few days and malfunction of backup power (i.e., diesel generators, if available).

- For **dispatch facilities with unanchored equipment**, DS3 is defined by moderate damage to building, or loss of off-site power for few days and malfunction of backup power (i.e., diesel generators, if available).

Extensive Damage (DS4)

- For railway tracks/roadbeds, DS4 is defined by major differential settlement of the ground resulting in potential derailment over extended length.

- For railway bridges, DS4 is defined the same as it is for highway bridges.

- For railway tunnels, DS4 is defined the same as it is for highway tunnels.

- For railway system facilities:

- For urban stations and maintenance facilities, DS4 is defined by extensive building damage (check Chapter 1 for description of potential damage).

- For fuel facilities with anchored equipment, DS4 is defined by elephant foot buckling of tanks with loss of contents, extensive damage to pumps (cracked/sheared shafts), or extensive damage to pump building.

- For fuel facilities with unanchored equipment, DS4 is defined by weld failure at base of tank with loss of contents, extensive damage to pump building, or extensive damage to pumps (cracked/sheared shafts).

- For fuel facilities with buried tanks, DS4 is defined by considerable uplift (more than a foot) of the tanks and rupture of the attached piping.

- For dispatch facilities with unanchored or anchored equipment, DS4 is defined by extensive building damage.

Complete Damage (DS5)

- For **railway tracks/roadbeds**, DS5 is the same as DS4.

- For **railway bridges**, DS5 is defined the same as it is for highway bridges.

- For **railway tunnels**, DS5 is defined the same as it is for highway tunnels.

- For **railway system facilities:**

- For **urban stations** and **maintenance facilities**, DS5 is defined by extensive to complete building damage (check Chapter 1 for description of potential damage).

- For **fuel facilities with anchored equipment**, DS5 is defined by weld failure at base of tank with loss of contents, or extensive to complete damage to pump building.

- For **fuel facilities with unanchored equipment**, DS5 is defined by tearing of tank wall or implosion of tank (with total loss of content), or extensive/complete damage to pump building.

- For **fuel facilities with buried tanks**, DS5 is same as DS4.

- For **dispatch facilities with unanchored or anchored equipment**, DS5 is defined by complete damage to building.

3.2.3. Functionality of Railway System Components

Component functionality is described similar to highway system components, that is, by the probability of being in a damage state (immediately following the earthquake) and by the associated fraction or percentage of the component that is expected to be functional after a specified period of time.

3.3. Light Rail Transportation System

3.3.1. Description of Light Rail Systems

Like railway systems, light rail systems consist of railway tracks/roadbeds, bridges, tunnels, maintenance facilities, dispatch facilities and DC power substations. The first five are the same as for railway systems and are already described in Section 3.2.1. Therefore, only DC substations will be described in this subsection.

DC Power Substations

Light rail systems use electric power and have low voltage DC power substations. DC power is used by the light rail system's electrical distribution system. The DC power substations consist of electrical equipment, which convert the local electric utility AC power to DC power. Two types of DC power stations are considered. These are: (1) DC power stations with anchored (seismically designed) components and (2) DC power stations with unanchored (which are not seismically designed) components.

3.3.2 Definitions of Damage States of Light Rail Systems

A total of five damage states are defined for light rail system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight or Minor Damage (DS2)

- For **tracks/roadbeds**, DS2 is defined similar to railway tracks.
- For **light rail bridges**, DS2 is defined similar to railway bridges.
- For **light rail tunnels**, DS2 is defined similar to highway tunnels.
- For **light rail system facilities**:
- For **maintenance facilities**, DS2 is defined similar to railway maintenance facilities.
- For **dispatch facilities**, DS2 is defined similar to railway dispatch facilities.
- For **DC power substations with anchored or unanchored components**, DS2 is defined by loss of off-site power for a very short period, or slight damage to building.

Moderate Damage (DS3)

- For **tracks/roadbeds**, DS3 is defined similar to railway tracks.
- For **light rail bridges**, DS3 is defined similar to railway bridges.
- For **light rail tunnels**, DS3 is defined similar to highway tunnels.
- For **light rail system facilities**:
- For **maintenance facilities**, DS3 is defined similar to railway maintenance facilities.
- For **dispatch facilities**, DS3 is defined similar to railway dispatch facilities.
- For **DC power substations with anchored or unanchored components**, DS3 is defined by loss of off-site power for few days, considerable damage to equipment, or moderate damage to building.

Extensive Damage (DS4)

- For **tracks/roadbeds**, DS4 is defined similar to railway tracks.
- For **light rail bridges**, DS4 is defined similar to railway bridges.
- For **light rail tunnels**, DS4 is defined similar to highway tunnels.
- For **light rail system facilities**:
- For **maintenance facilities**, DS4 is defined similar to railway maintenance facilities.

- For **dispatch facilities**, DS4 is defined similar to railway dispatch facilities.

- For **DC power substations with anchored or unanchored components**, DS4 is defined by extensive building damage.

<u>**Complete Damage (DS5)**</u>

- For tracks/roadbeds, DS5 is defined similar to railway tracks.

- For light rail bridges, DS5 is defined similar to railway bridges.

- For light rail tunnels, DS5 is defined similar to highway tunnels.

- For light rail system facilities:

- For maintenance facilities, DS5 is defined similar to railway maintenance facilities.

- For dispatch facilities, DS5 is defined similar to railway dispatch facilities.

- For DC power substations with anchored or unanchored components, DS5 is defined by complete building damage.

3.3.3. Functionality of Light Rail Systems

Component functionality is described by the probability of damage state (immediately following the earthquake) and by the associated fraction or percentage of the component that is expected to be functional after a specified period of time.

3.4. Bus Transportation System

3.4.1. Description of Bus System Components

A bus system consists mainly of four components: urban stations, fuel facilities, maintenance facilities, and dispatch facilities. Major losses can occur if bus maintenance buildings collapse and operational problems may arise if a dispatch facility is damaged. This section provides a brief description of each component.

Urban Stations

These are mainly buildings structures.

Bus System Fuel Facilities

Fuel facility consists of fuel storage tanks, buildings, pump equipment and buried pipe, and, sometimes, backup power. The fuel facility functionality is determined with a fault tree analysis considering redundancies and sub-component behavior. The same classes assumed for railway fuel facilities are assumed here.

Bus System Maintenance Facilities
Maintenance facilities for bus systems are mostly made of steel braced frames. The same classes assumed for railway maintenance facilities are assumed here.

Bus System Dispatch Facilities
The same classes assumed for railway dispatch facilities are assumed here.

3.4.2 Definitions of Damage States of Bus System Components

Damage states describing the level of damage to each of the bus system components are defined (i.e. slight, moderate, extensive or complete). Damage states are related to damage ratio (defined as ratio of repair to replacement cost) for evaluation of direct economic loss.

For bus systems, the restoration is dependent upon the extent of damage to the fuel, maintenance, and dispatch facilities.

3.4.3 Definitions of Damage States of Bus System Components

A total of five damage states are defined for bus system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight Damage (DS2)

- For **urban stations**, DS2 is defined similar to railway urban stations.
- For **fuel facilities**, DS2 is defined similar to railway fuel facilities.
- For **maintenance facilities**, DS2 is defined similar to railway maintenance facilities.
- For **dispatch facilities**, DS2 is defined similar to railway dispatch facilities.

Moderate Damage (DS3)

- For **urban stations**, DS3 is defined similar to railway urban stations.
- For **fuel facilities**, DS3 is defined similar to railway fuel facilities.

- For **maintenance facilities**, DS3 is defined similar to railway maintenance facilities.
- For **dispatch facilities**, DS3 is defined similar to railway dispatch facilities.

Extensive Damage (DS4)

- For **urban stations**, DS4 is defined similar to railway urban stations.
- For **fuel facilities**, DS4 is defined similar to railway fuel facilities.
- For **maintenance facilities**, DS4 is defined similar to railway maintenance facilities.
- For **dispatch facilities**, DS4 is defined similar to railway dispatch facilities.

Complete Damage (DS5)

- For **urban stations**, DS5 is defined similar to railway urban stations.
- For **fuel facilities**, DS5 is defined similar to railway fuel facilities.
- For **maintenance facilities**, DS5 is defined similar to railway maintenance facilities.
- For **dispatch facilities**, DS5 is defined similar to railway dispatch facilities.

3.4.4. Functionality of Bus Transportation Systems

Component functionality is described by the probability of being in a damage state (immediately following the earthquake) and by the associated fraction or percentage of the component that is expected to be functional after a specified period of time.

3.5. Port Transportation Systems

3.5.1. Description of Port Transportation Systems

A port system consists of four components: waterfront structures, cranes/cargo handling equipment, fuel facilities, and warehouses. In many cases, these facilities were constructed prior to widespread use of engineered fills; consequently, the wharf, pier, and seawall structures are prone to damage due to soil failures such as liquefaction. This section provides a brief description of each.

Waterfront Structures

This component includes wharves (port embankments), seawalls (protective walls from erosion), and piers (break-water structures which form harbors) that exist in the port system. Waterfront structures typically are supported by wood, steel or concrete piles. Many also have batter piles to resist lateral loads from wave action and impact of vessels. Seawalls are caisson walls retaining earth fill material.

Cranes and Cargo Handling Equipment

These are large equipment items used to load and unload freight from vessels. These are can be stationary or mounted on rails.

Port Fuel Facilities

The fuel facility consists mainly of fuel storage tanks, buildings, pump equipment, piping, and, sometimes, backup power. These are the same as those for railway systems presented in Section 3.2.1.

Warehouses

Warehouses are large buildings usually constructed of structural steel. In some cases, warehouses may be several hundred feet from the shoreline, while in other instances; they may be located on the wharf itself.

3.5.2. Definition of Damage States of Port Transportation Systems

A total of five damage states are defined for port system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

<u>Slight/Minor Damage (DS2)</u>

- For **waterfront structures**, DS2 is defined by minor ground settlement resulting in few piles (for piers/seawalls) getting broken and damaged. Cracks are formed on the surface of the wharf. Repair may be needed.

- For **cranes/cargo handling equipment**, DS2 is defined by slight damage to structural members with no loss of function for the stationary equipment, while for the unanchored or rail mounted equipment, DS1 is defined as minor derailment or misalignment without any major structural damage to the rail mount. Minor repair and adjustments may be required before the crane becomes operable.

- For **fuel facilities**, DS2 is defined the same as it is for railway facilities.

- For **warehouses**, DS2 is defined by slight damage to the warehouse building.

Moderate Damage (DS3)

- For **waterfront structures**, DS3 is defined as considerable ground settlement with several piles (for piers/seawalls) getting broken and damaged.

- For **cranes/cargo handling equipment**, DS3 is defined as derailment due to differential displacement of parallel track. Rail repair and some repair to structural members is required.

- For **fuel facilities**, DS3 is defined the same as it is for railway facilities.

- For **warehouses**, DS3 is defined by moderate damage to the warehouse building.

Extensive Damage (DS4)

- For **waterfront structures**, DS4 is defined by failure of many piles, extensive sliding of piers, and significant ground settlement causing extensive cracking of pavements.

- For **cranes/cargo handling equipment**, DS4 is defined by considerable damage to equipment. Toppled or totally derailed cranes are likely to occur. Replacement of structural members is required.

- For **fuel facilities**, DS4 is defined same as for railway facilities.

- For **warehouses**, DS4 is defined by extensive damage to warehouse building.

3.5.3. Functionality of Port Transportation Systems

For ports the restoration is dependent upon the extent of damage to the waterfront structures, cranes/cargo handling equipment, fuel facilities, and warehouses. From the standpoint of functionality of the port, the user should consider the restoration of only the waterfront structures and cranes since the fuel facilities and warehouses are not as critical to the functionality of the port.

3.6. Ferry Transportation System

3.6.1. Description of Ferry System Components

A ferry system consists of five components: waterfront structures, fuel facilities, maintenance facilities, dispatch facilities, and passenger terminals. This section provides a brief description of each.

Waterfront Structures

The waterfront structures are located at the points of embarkation or disembarkation, and they are similar to, although not as extensive as, those of the port transportation system described in Section 3.5.1.

Fuel Facilities

These facilities are usually located at one of the two points of embarkation and they are similar to those for port system mentioned in Section 3.5.1.

Maintenance Facilities

These facilities are usually located at one of the two points of embarkation and they are often steel braced frame structures, but other building types are possible.

Dispatch Facilities

These facilities are usually located at one of the two points of embarkation and they are similar to those defined for railway system in Section 3.2.1.

Passenger Terminals

These facilities are usually located at one of the two points of embarkation and they are often moment resisting steel frames, but other building types are possible.

3.6.2. Definitions of Ferry System Components

A total of five damage states are defined for ferry system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight/Minor Damage (DS2)

- For **waterfront structures**, DS2 is the same as that for waterfront structures in the port module.

- For **fuel facilities**, DS2 is the same as that for fuel facilities in the port module.

- For **maintenance facilities**, DS2 is defined by slight damage to building.

- For **dispatch facilities**, DS2 is the same as that for dispatch facilities in the railway module.

- For **passenger terminals**, DS2 is defined by slight damage to building.

Moderate Damage (DS3)

- For **waterfront structures**, DS3 is the same as that for waterfront structures in the port module.

- For **fuel facilities**, DS3 is the same as that for fuel facilities in the port module.

- For **maintenance facilities**, DS3 is defined by moderate damage to building.

- For **dispatch facilities**, DS3 is the same as that for dispatch facilities in the railway module.

- For **passenger terminals**, DS3 is defined by moderate damage to building.

Extensive Damage (DS4)

- For **waterfront structures**, DS4 is the same as that for waterfront structures in the port module.

- For **fuel facilities**, DS4 is the same as that for fuel facilities in the port module.

- For **maintenance facilities**, DS4 is defined by extensive damage to building.

- For **dispatch facilities**, DS4 is the same as that for dispatch facilities in the railway
- module.

- For **passenger terminals**, DS4 is defined by extensive damage to building.

Complete Damage (DS5)

- For **waterfront structures**, DS5 is the same as that for waterfront structures in the port module.

- For **fuel facilities**, DS5 is the same as that for fuel facilities in the port module.

- For **maintenance facilities**, DS5 is defined by complete damage to building.

- For **dispatch facilities**, DS5 is the same as that for dispatch facilities in the railway module.

- For **passenger terminals**, DS5 is defined as complete damage to building.

3.6.3. Functionality of Ferry System Components

Restoration curves describe the fraction or percentage of the component that is expected to be open or operational as a function of time following the earthquake. For ferries the restoration is dependent upon the extent of damage to the waterfront structures; fuel, maintenance, and dispatch facilities; and passenger terminals.

Interdependence of components on overall system functionality is not addressed by the methodology. Such considerations require a system (network) analysis that would be performed separately by a transportation system expert as an advanced study.

3.7. Airport Transportation System

3.7.1. Description of Airport Components

An airport system consists of the six components mentioned above: runways, control tower, fuel facilities, maintenance facilities, and parking structures. For airports, control towers are often constructed of reinforced concrete, while terminal buildings and maintenance facilities are often constructed of structural steel or reinforced concrete. This section provides a brief description of each.

Runways

This component consists of well-paved "flat and wide surfaces".

Control Tower

Control tower consists of a building and the necessary equipment of air control and monitoring.

Fuel Facilities

These have been previously defined in Section 3.2.1. of railway systems.

Terminal Buildings

These are similar to urban stations of railway systems from the classification standpoint (as well as services provided to passengers).

Maintenance Facilities, Hangar Facilities, and Parking Structures

Classification of maintenance facilities is the same as for those in railway systems. Hangar facilities and parking structures are mainly composed of buildings.

3.7.2. Definitions of Damage States

A total of five damage states are defined for airport system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight/Minor Damage (DS2)

- For **runways**, DS2 is defined as minor ground settlement or heaving of runway surface.

- For **control tower**, DS2 is defined as slight damage to the building as given in Section 1.4.

- For **fuel facilities**, DS2 is the same as that for fuel facilities in the railway module.

- For **terminal buildings**, DS2 is defined as slight damage to the building as given in Section 1.4.

- For **maintenance and hangar facilities**, DS2 is defined as slight damage to the building as given in Section 1.4.
- For **parking structures**, DS2 is defined as slight damage to the building as given in Section 1.4.

Moderate Damage (DS3)

- For **runways**, DS3 is defined same as DS2.

- For **control tower**, DS3 is defined as moderate damage to the building as given in Section 1.4.

- For **fuel facilities**, DS3 is the same as that for fuel facilities in the railway module.

- For **terminal buildings**, DS3 is defined as moderate damage to the building as given in Section 1.4.

- For **maintenance and hangar facilities**, DS3 is defined as moderate damage to the building as given in Section 1.4.

- For **parking structures**, DS3 is defined as moderate damage to the building as given in Section 1.4.

Extensive Damage (DS4)

- For **runways**, DS4 is defined as considerable ground settlement or considerable heaving of runway surface.

- For **control tower**, DS4 is defined as extensive damage to the building as given in section 5.3.

- For **fuel facilities**, DS4 is the same as that for fuel facilities in the railway module.

- For **terminal buildings**, DS4 is defined as extensive damage to the building as given in Section 1.4.

- For **maintenance and hangar facilities**, DS4 is defined as extensive damage to the building as given in Section 1.4.

- For **parking structures**, DS4 is defined as extensive damage to the building as given in Section 1.4.

Complete Damage (DS5)

- For **runways**, DS5 is defined as extensive ground settlement or excessive heaving of runway surface.

- For **control tower**, DS5 is defined as complete damage to the building as given in section 5.3.

- For **fuel facilities**, DS5 is the same as that for fuel facilities in the railway module.

- For **terminal buildings**, DS5 is defined as complete damage to the building as given in Section 1.4.

- For **maintenance and hangar facilities**, DS5 is defined as complete damage to the building as given in Section 1.4.

- For **parking structures**, DS5 is defined as complete damage to the building as given in Section 1.4.

3.7.3. Definition of Functionality of Highway Components

Component restoration curves are provided for each damage state to evaluate loss of function. Restoration curves describe the fraction or percentage of the component that is expected to be open or operational as a function of time following the earthquake. For airports, the restoration is dependent upon the extent of damage to the airport terminals, buildings, storage tanks (for fuel facilities), control tower, and runways.

4. Utility Systems

The Utility Module is composed of the following six systems:

- Potable Water
- Waste Water
- Oil (crude and refined)
- Natural Gas
- Electric Power
- Communication

4.1. Potable Water Systems

This system consists of supply, storage, transmission, and distribution components. All of these components are vulnerable to damage during earthquakes, which may result in a significant disruption to the water utility network.

4.1.1 Description of Potable Water System Components

A potable water system typically consists of terminal reservoirs, water treatment plants, wells, pumping plants, storage tanks and transmission and distribution pipelines. In this subsection, a brief description of each of these components is presented.

Terminal Reservoirs

Terminal reservoirs are typically lakes (man made or natural) and are usually located nearby and upstream of the water treatment plant. Vulnerability of terminal reservoirs and associated dams is marginally assessed in the loss estimation methodology. Therefore, even though reservoirs are an essential part of a potable water system, it is assumed in the analysis of water systems that the amount of water flowing into water treatment plants from reservoirs right after an earthquake is essentially the same as before the earthquake.

Transmission Aqueducts

These transmission conduits are typically large size pipes (more than 20 inches in diameter) or channels (canals) that convey water from its source (reservoirs, lakes, rivers) to the treatment plant. Transmission pipelines are commonly made of concrete, ductile iron, cast iron, or steel. These could be elevated/at grade or buried. Elevated or at grade pipes are typically made of steel (welded or riveted), and they can run in single or multiple lines. Canals are typically lined with concrete, mainly to avoid excessive loss of water by seepage and to control erosion. In addition to concrete lining, expansion joints are usually used to account for swelling and shrinkage under varying temperature and moisture conditions. Damageability of channels has occurred in some earthquake, but is outside the scope of the scope of the methodology.

Supply Facilities- Water Treatment Plants (WTP)

Water treatment plants are generally composed of a number of physical and chemical unit processes connected in series, for the purpose of improving the water quality. A conventional WTP consists of a coagulation process, followed by a sedimentation process, and finally a filtration process. Alternately, a WTP can be regarded as a system of interconnected pipes, basins, and channels through which the water moves, and where the flow is governed by hydraulic principles. WTP are categorized as follows:

Small water treatment plants, with capacity ranging from 10 mgd to 50 mgd, are assumed to consist of a filter gallery with flocculation tanks (composed of paddles and baffles) and settling (or sedimentation) basins as main components, chemical tanks (needed in the coagulation and other destabilization processes), chlorination tanks, electrical and mechanical equipment, and elevated pipes.
Medium water treatment plants, with capacity ranging from 50 mgd to 200 mgd, are simulated by adding more redundancy to small treatment plants (i.e. twice as many flocculation, sedimentation, chemical and chlorination tanks).

Large water treatment plants, with capacity above 200 mgd, are simulated by adding even more redundancy to small treatment plants (i.e., three times as many flocculation, sedimentation, chemical and chlorination tanks/basins).

Water treatment plants are also classified based on whether the subcomponents (equipment and backup power) are anchored or not as defined in section 3.2.1.

Pumping Plants (PP)

Pumping plants are usually composed of a building, one or more pumps, electrical equipment, and in some cases, backup power systems. Pumping plants are classified as either small PP (less than 10 mgd capacity) or medium/large PP (more than 10 mgd capacity). Pumping plants are also classified with respect to whether the subcomponents (equipment and backup power) are anchored or not. As noted in Chapter 3.2.1, anchored means equipment designed with special seismic tie downs and tiebacks while unanchored means equipment with manufactures normal requirements.

Wells (WE)

Wells typically have a capacity between 1 and 5 mgd. Wells are used in many cities as a primary or supplementary source of water supply. Wells include a shaft from the surface down to the aquifer, a pump to bring the water up to the surface, equipment used to treat the water, and sometimes a building, which encloses the well and equipment.

Water Storage Tanks (ST)

Water storage tanks can be elevated steel, on ground steel (anchored/unanchored), on ground concrete (anchored/unanchored), buried concrete, or on ground wood tanks. Typical capacity of storage tanks is in the range of 0.5 mgd to 2 mgd.

Distribution Facilities and Distribution Pipes

Distribution of water can be accomplished by gravity, or by pumps in conjunction with on-line storage. Except for storage reservoirs located at a much higher altitude than the area being served, distribution of water would necessitate, at least, some pumping along the way. Typically, water is pumped at a relatively constant rate, with flow in excess of consumption being stored in elevated storage tanks. The stored water provides a reserve for fire flow and may be used for general-purpose flow should the electric power fail, or in case of pumping capacity loss. Distribution pipelines are commonly made of concrete (prestressed or reinforced), asbestos cement, ductile iron, cast iron, steel, or plastic. The selection of material type and pipe size are based on the desired carrying capacity, availability of material, durability, and cost. Distribution pipes represent the network that delivers water to consumption areas. Distribution pipes may be further subdivided into primary lines, secondary lines, and small distribution mains. The primary or arterial mains carry flow from the pumping station to and from elevated storage tanks, and to the consumption areas, whether residential, industrial, commercial, or public. These lines are typically laid out in interlocking loops, and all smaller lines connecting to them are typically valved so that failure in smaller lines does not require shutting off the larger. Primary lines can be up to 36 inches in diameter. Secondary lines are smaller loops within the primary mains and run from one primary line to another. They serve primarily to provide a large amount of water for fire fighting without excessive pressure loss. Small distribution lines represent the mains that supply water to the user and to the fire hydrants. In this earthquake loss estimation study, the simplified method for water system network performance evaluation applies to a distribution pipe network digitized at the primary level.

4.1.2 Definition of Damage States of Potable Water System Components

Potable water systems are susceptible to earthquake damage. Facilities such as water treatment plants; wells, pumping plants and storage tanks are most vulnerable to PGA, and sometimes PGD, if located in liquefiable or landslide zones. Therefore, the damage states for these components are defined and associated with PGA and PGD. Aqueducts and pipelines, on the other hand, are vulnerable to PGV and PGD. Therefore, the damage states for these components are associated with these two ground motion parameters.

Damage states describing the level of damage to each of the water system components are defined (i.e., slight/minor, moderate, extensive, or complete), while for pipelines, the number of repairs/km is the key parameter.

4.1.2.1. Damage State Definitions for Components Other than Pipelines

A total of five damage states for potable water system components are defined. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4), and complete (DS5).

Slight/Minor Damage (DS2)

- For **water treatment plants**, DS2 is defined by malfunction of plant for a short time (less than three days) due to loss of electric power and backup power if any, considerable damage to various equipment, light damage to sedimentation basins, light damage to chlorination tanks, or light damage to chemical tanks. Loss of water quality may occur.

- For **pumping plants**, DS2 is defined by malfunction of plant for a short time (less than three days) due to loss of electric power and backup power if any, or slight damage to buildings.

- For **wells**, DS2 is defined by malfunction of well pump and motor for a short time (less than three days) due to loss of electric power and backup power if any, or light damage to buildings.

- For **storage tanks**, DS2 is defined by the tank suffering minor damage without loss of its contents or functionality. Minor damage to the tank roof due to water sloshing, minor cracks in concrete tanks, or localized wrinkles in steel tanks fits the description of this damage state.

Moderate Damage (DS3)

- For **water treatment plants**, DS3 is defined by malfunction of plant for about a week due to loss of electric power and backup power if any, extensive damage to various equipment, considerable damage to sedimentation basins, considerable damage to chlorination tanks with no loss of contents, or considerable damage to chemical tanks. Loss of water quality is imminent.

- For **pumping plants**, DS3 is defined by the loss of electric power for about a week, considerable damage to mechanical and electrical equipment, or moderate damage to buildings.

- For **wells**, DS3 is defined by malfunction of well pump and motor for about a week due to loss of electric power and backup power if any, considerable damage to mechanical and electrical equipment, or moderate damage to buildings.
- For **Storage Tanks**, DS3 is defined by the tank being considerably damaged, but only minor loss of content. Elephant foot buckling for steel tanks without loss of content or moderate cracking of concrete tanks with minor loss of content fits the description of this damage state.

Extensive Damage (DS4)

- For **water treatment plants**, DS4 is defined by the pipes connecting the different basins and chemical units being extensively damaged. This type of damage will likely result in the shutdown of the plant.

- For **pumping plants**, DS4 is defined by the building being extensively damaged, or the pumps being badly damaged beyond repair.

- For **wells**, DS4 is defined by the building being extensively damaged or the well pump and vertical shaft being badly distorted and nonfunctional.

- For **Storage Tanks**, DS4 is defined by the tank being severely damaged and going out of service. Elephant foot buckling for steel tanks with loss of content, stretching of bars for wood tanks, or shearing of wall for concrete tanks fits the description of this damage state.

Complete Damage (DS5)

- For **water treatment plants**, DS5 is defined by the complete failure of all pipings, or extensive damage to the filter gallery.

- For **pumping plants**, DS5 is defined by the building collapsing.

- For **wells**, DS5 is defined by the building collapsing.

- For **Storage Tanks**, DS5 is defined by the tank collapsing and losing all of its content.

4.1.2.1. Damage State Definitions for Pipelines

For pipelines, two damage states are considered. These are leaks and breaks. Generally, when a pipe is damaged due to ground failure (PGD), the type of damage is likely to be a break, while when a pipe is damaged due to seismic wave propagation (PGV), the type of damage is likely to be joint pull-out or crushing at the bell.

4.1.3 Functionality of Potable Water System Pipelines

The loss assessment methodology estimates the flow reduction to the areas served by the water system being evaluated. In other words, a functionality of 50% means that 50% of the population would be affected because of potable water disruption.

4.2. Waste Water Systems

This system consists of transmission and treatment components. These components are vulnerable to damage during earthquakes, which may result in significant disruption to the utility network.

4.2.1 Description of Waste Water System Components

A waste water system typically consists of collection sewers, interceptors, lift stations, and wastewater treatment plants. In this section, a brief description of each of these components is given.

Collection Sewers

Collection sewers are generally closed conduits that carry normally sewage with a partial flow. Collection sewers could be sanitary sewers, storm sewers, or combined sewers. Pipe materials that are used for potable water transportation may also be used for wastewater collection. The most commonly used sewer material is clay pipe manufactured with integral bell and spigot end. These pipes range in size from 4 to 42 inches in diameter. Concrete pipes are mostly used for storm drains and for sanitary sewers carrying noncorrosive sewage (i.e. with organic materials). For the smaller diameter range, plastic pipes are also used.

Interceptors

Interceptors are large diameter sewer mains. They are usually located at the lowest elevation areas. Pipe materials that are used for interceptor sewers are similar to those used for collection sewers.

Lift Stations (LS)

Lift stations are important parts of the waste water system. Lift stations serve to raise sewage over topographical rises. If the lift station is out of service for more than a short time, untreated sewage will either spill out near the lift station, or back up into the collection sewer system. In this study, lift stations are classified as either small LS (capacity less than 10 mgd) or medium/large LS (capacity greater than 10 mgd). Lift stations are also classified as having either anchored or unanchored subcomponents (see Section 3.2.1 for the definition of anchored and unanchored subcomponents)

Waste Water Treatment Plants (WWTP)

Three sizes of wastewater treatment plants are considered: small (capacity less than 50 mgd), medium (capacity between 50 and 200 mgd), and large (capacity greater than 200 mgd). WWTP has the same processes existing in WTP with the addition of secondary treatment subcomponents.

4.2.2 Definitions of Damage States of Waste Water System Components

Waste water systems are susceptible to earthquake damage. Facilities such as waste water treatment plants and lift stations are mostly vulnerable to PGA, and sometimes PGD, if located in liquefiable or landslide zones. Therefore, the damage states for these components are defined and associated with PGA and PGD. Sewers, on the other hand, are vulnerable to PGV and PGD. Therefore, the damage algorithms for these components are associated with those two ground motion parameters.

4.2.2.1. Damage States Definitions for Components other than Sewers/Interceptors

A total of five damage states are defined for waste water system components other than sewers and interceptors. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight/Minor Damage (DS2)

- For **waste water treatment plants**, DS2 is defined as for WTP in potable water systems.

- For **lift stations**, DS2 is defined as for pumping plants in potable water systems.

Moderate Damage (DS3)

- For **waste water treatment plants**, DS3 is defined as for WTP in potable water systems.

- For **lift stations**, DS3 is defined as for pumping plants in potable water systems.

Extensive Damage (DS4)

- For **waste water treatment plants**, DS4 is defined as for WTP in potable water systems.

- For **lift stations**, DS4 is defined as for pumping plants in potable water systems.

Complete Damage (DS5)

- For **waste water treatment plants**, DS5 is defined as for WTP in potable water systems.

- For **lift stations**, DS5 is defined as for pumping plants in potable water systems.

4.2.2.2. Damage States Definitions for Sewers/Interceptors

For sewers/interceptors, two damage states are considered. These are leaks and

breaks. Generally, when a sewer/interceptor is damaged due to ground failure, the type of damage is likely to be a break, while when a sewer/interceptor is damaged due to seismic wave propagation; the type of damage is likely to be joint pullout or crushing at the bell. In the loss methodology, it is assumed that damage due to seismic waves will consist of 80% leaks and 20% breaks, while damage due to ground failure will consist of 20% leaks and 80% breaks. The user can override these default percentages.

4.3. Oil Systems

This system consists of refineries and transmission components. These components are vulnerable to damage during earthquakes, which may result in significant disruption to this utility network.

4.3.1. Description of Oil System Components

An oil system typically consists of refineries, pumping plants, tank farms, and pipelines. In this section, a brief description of each of these components is given.

Refineries (RF)

Refineries are an important part of an oil system. They are used for processing crude oil before it can be used. Although supply of water is critical to the functioning of refinery, it is assumed in the methodology that an uninterrupted supply of water is available to the refinery. Two sizes of refineries are considered: small, and medium/large.

Small refineries (capacity less than 100,000 barrels per day), are assumed to consist of steel tanks on grade, stacks, other electrical and mechanical equipment, and elevated pipes. Stacks are essentially tall cylindrical chimneys.

Medium/Large refineries (capacity more than 100,000 barrels per day), are simulated by adding more redundancy to small refineries (i.e. twice as many tanks, stacks, elevated pipes).

Oil Pipelines

Oil pipelines are used for the transportation of oil over long distances. About seventy-five percent of the crude oil is transported throughout the United States by pipelines. A large segment of industry and millions of people could be severely affected by disruption of crude oil supplies. Rupture of crude oil pipelines could lead to pollution of land and rivers. Pipelines are typically made of mild steel with submerged arc welded joints, although older gas welded steel pipe may be present in some systems. In this study, buried pipelines are considered to be vulnerable to PGV and PGD.

Pumping Plants (PP)

Pumping plants serve to maintain the flow of oil in cross-country pipelines. Pumping plants usually use two or more pumps. Pumps can be of either centrifugal or reciprocating type. However, no differentiation is made between these two types of pumps in the analysis of oil systems. Pumping plants are classified as having either anchored or unanchored subcomponents, as defined in 3.2.1.

Tank Farms (TF)

Tank farms are facilities that store fuel products. They include tanks, pipes and electric components. Tank farms are classified as having either anchored or unanchored subcomponents, as defined in Section 3.2.1.

4.3.2. Definitions of Damage States of Oil System Components

Oil systems are susceptible to earthquake damage. Facilities such as refineries, pumping plants and tank farms are mostly vulnerable to PGA, and sometimes PGD, if located in liquefiable or landslide zones. Therefore, the damage states for these components are defined and associated with PGA and PGD. Pipelines, on the other hand, are vulnerable to PGV and PGD. Therefore, the damage states for these components are associated with these two ground motion parameters.

4.3.2.1 Damage States Definitions for Components other than Pipelines

A total of five damage states are defined for oil system components other than pipelines. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight/Minor Damage (DS2)

- For **refineries**, DS2 is defined by malfunction of plant for a short time (few days) due to loss of electric power and backup power, if any, or light damage to tanks.

- For **pumping plants**, DS2 is defined by light damage to building.

- For **tank farms**, DS2 is defined by malfunction of plant for a short time (less than three days) due to loss of backup power or light damage to tanks.

Moderate Damage (DS3)

- For **refineries**, DS3 is defined by malfunction of plant for a week or so due to loss of electric power and backup power if any, extensive damage to various equipment, or considerable damage to tanks.

- For **pumping plants**, DS3 is defined by considerable damage to mechanical and electrical equipment, or considerable damage to building.

- For **tank farms**, DS3 is defined by malfunction of tank farm for a week or so due to loss of backup power, extensive damage to various equipment, or considerable damage to tanks.

Extensive Damage (DS4)

- For **refineries**, DS4 is defined by the tanks being extensively damaged, or stacks collapsing.

- For **pumping plants**, DS4 is defined by the building being extensively damaged, or pumps badly damaged.

- For **tank farms**, DS4 is defined by the tanks being extensively damaged, or extensive damage to elevated pipes.

Complete Damage (DS5)

- For **refineries**, DS5 is defined by the complete failure of all elevated pipes, or collapse of tanks.

- For **pumping plants**, DS5 is defined by the building being in complete damage state.

- For **tank farms**, DS5 is defined by the complete failure of all elevated pipes, or collapse of tanks.

4.3.2.2. Damage State Definitions for Pipelines

For pipelines, two damage states are considered. These are leaks and breaks. Generally, when a pipe is damaged due to ground failure, the type of damage is likely to be a break, while when a pipe is damaged due to seismic wave propagation; the type of damage is likely to be local buckling of the pipe wall.

4.4. Natural Gas Systems

4.4.1. Description of Natural Gas System Components

A natural gas system typically consists of compressor stations and pipelines. In this section, a brief description of each of these components is given.

Compressor Stations

Compressor stations serve to maintain the flow of gas in cross-country pipelines. Compressor stations consist of either centrifugal or reciprocating compressors. However, no differentiation is made between these two types of compressors in the analysis of natural gas systems. Compressor stations are categorized as having either anchored or unanchored subcomponents, as defined in Section 3.2.1. The compressor stations are similar to pumping plants in oil systems discussed in Section 4.3.1.

Natural Gas Pipelines

Pipelines are typically made of mild steel with submerged arc welded joints, although older lines may have gas-welded joints. These are used for the transportation of natural gas over long distances. Many industries and residents could be severely affected should disruption of natural gas supplies occur.

4.4.2 Definitions of Damage States of Natural Gas System Components

Facilities such as compressor stations are mostly vulnerable to PGA, sometimes PGD, if located in liquefiable or landslide zones. Therefore, damage states for these components are defined and associated with either PGA or PGD. Pipelines, on the other hand, are vulnerable to PGV and PGD; therefore, damage states for these components are associated with these two ground motion parameters.

4.4.2.1 Damage States Definitions for Compressor Stations

A total of five damage states are defined for gas system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight/Minor Damage (DS2)

DS2 is defined by slight damage to building.

Moderate Damage (DS3)

DS3 is defined by considerable damage to mechanical and electrical equipment, or considerable damage to building.

Extensive Damage (DS4)

DS4 is defined by the building being extensively damaged or the pumps badly damaged beyond repair.

Complete Damage (DS5)

DS5 is defined by the building in complete damage state.

4.4.2.2 Damage States Definitions for Pipelines

For pipelines, two damage states are considered. These are leaks and breaks. Generally, when a pipe is damaged due to ground failure, the type of damage is likely to be a break, while when a pipe is damaged due to seismic wave propagation; the type of damage is likely to be local bucking of the pipe wall. In the loss methodology, it is assumed that damage due to seismic waves will consist of 80% leaks and 20% breaks, while damage due to ground failure will consist of 20% leaks and 80% breaks. The user can override these default percentages.

4.5. Electric Power Systems

4.5.1. Description of Electric Power System Components

As mentioned before, the components of an electric power system considered in the loss estimation methodology are substations, distribution circuits, and generation plants. In this section a brief description of each of these components is presented.

Substations

An electric substation is a facility that serves as a source of energy supply for the local distribution area in which it is located, and has the following main functions:
- Change or switch voltage from one level to another.
- Provide points where safety devices such as disconnect switches, circuit breakers, and other equipment can be installed.
- Regulate voltage to compensate for system voltage changes.
- Eliminate lightning and switching surges from the system.
- Convert AC to DC and DC to AC, as needed.
- Change frequency, as needed.

Substations can be entirely enclosed in buildings where all the equipment is assembled into one metal clad unit. Other substations have step-down transformers, high voltage switches, oil circuit breakers, and lightning arrestors located outside the substation building. In the current loss estimation methodology, only transmission (138 kV to 765 kV or higher) and subtransmission (34.5 kV to 161 kV) substations are considered. These will be classified as high voltage (350 kV and above), medium voltage (150 kV to 350 kV) and low voltage (34.5 kV to 150 kV), and will be referred to as 500 kV substations, 230kV substations, and 115kV substations, respectively. The classification is also a function of whether the subcomponents are anchored or typical (unanchored), as defined in Section 3.2.1.

Distribution Circuits

The distribution system is divided into a number of circuits. A distribution circuit includes poles, wires, in-line equipment and utility-owned equipment at customer sites. A distribution circuit also includes above ground and underground conductors. Distribution circuits either consist of anchored or unanchored components.

Generation Plants

These plants produce alternating current (AC) and may be any of the following types:
- Hydroelectric
- Steam turbine (fossil fuel fired or nuclear)
- Combustion turbine (fossil fuel fired)
- Geothermal
- Solar
- Wind
- Compressed air

Fossil fuels are either: coal, oil, or natural gas. Generation plant subcomponents include diesel generators, turbines, racks and panels, boilers and pressure vessels, and the building in which these are housed. The size of the generation plant is determined from the number of Megawatts of electric power that the plant can produce under normal operations. Small generation plants have a generation capacity of less than 200 Megawatts. Medium/Large generation plants have a capacity greater than 200 Megawatts. Fragility curves for generation plants with anchored versus unanchored subcomponents are presented.

4.5.2. Definitions of Damage States of Electric Power Systems

Electric power systems are susceptible to earthquake damage. Facilities such as substations, generation plants, and distribution circuits are mostly vulnerable to PGA, and sometimes PGD, if located in liquefiable or landslide zones. Therefore, the damage states for these components are defined in terms of PGA and PGD. A total of five damage states are defined for electric power system components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Note that for power systems, in particular for substations and distribution circuits, these damage states are defined with respect to the percentage of subcomponents being damaged. That is, for a substation with n1 transformers, n2 disconnect switches, n3 circuit breakers, and n4 current transformers, the substation is said to be in a slight or minor damage state if 5% of n2 or 5% of n3 are damaged, and it is in the extensive damage state if 70% of n1, 70% of n2, or 70% of n3 are damaged, or if the building is in extensive damage state. A parametric study on n1, n2, n3, and n4 values shows that the medians of the damage states defined in this manner don't change appreciably (less than 3 %) as the ni's vary, while the corresponding dispersions get smaller as the ni's increase.

Therefore, we used dispersions obtained from the small sample numbers along with the relatively constant median values.

Slight/Minor Damage (DS2)

- For **substations**, DS2 is defined as the failure of 5% of the disconnect switches (i.e., misalignment), or the failure of 5 % of the circuit breakers (i.e., circuit breaker phase sliding off its pad, circuit breaker tipping over, or interrupter-head falling to the ground), or by the building being in minor damage state.

- For **distribution circuits**, DS2 is defined by the failure of 4 % of all circuits.

- For **generation plants**, DS2 is defined by turbine tripping, or light damage to diesel generator, or by the building being in minor damage state.

Moderate Damage (DS3)

- For **substations**, DS3 is defined as the failure of 40% of disconnect switches (e.g., misalignment), or 40% of circuit breakers (e.g., circuit breaker phase sliding off its pad, circuit breaker tipping over, or interrupter-head falling to the ground), or failure of 40% of current transformers (e.g., oil leaking from transformers, porcelain cracked), or by the building being in moderate damage state.

- For **distribution circuits**, DS3 is defined by the failure of 12% of circuits.

- For **generation plants**, DS3 is defined some by the chattering of instrument panels and racks, considerable damage to boilers and pressure vessels, or by the building being in moderate damage state.

Extensive Damage (DS4)

- For **substations**, DS4 is defined as the failure of 70% of disconnect switches (e.g., misalignment), 70% of circuit breakers, 70% of current transformers (e.g., oil leaking from transformers, porcelain cracked), or by failure of 70% of transformers (e.g., leakage of transformer radiators), or by the building being in extensive damage state.

- For **distribution circuits**, DS4 is defined by the failure of 50% of all circuits.

- For **generation plants**, DS4 is defined by considerable damage to motor driven pumps, or considerable damage to large vertical pumps, or by the building being in extensive damage state.

Complete Damage (DS5)

- For **substations**, DS5 is defined as the failure of all disconnect switches, all circuit breakers, all transformers, or all current transformers, or by the building being in complete damage state.

- For **distribution circuits**, DS5 is defined by the failure of 80% of all circuits.

- For **generation plants**, DS5 is defined by extensive damage to large horizontal vessels beyond repair, extensive damage to large motor operated valves, or by the building being in complete damage state.

4.6. Communication Systems

The major components of a communication system are:

- Central offices and broadcasting stations (this includes all subcomponents such as central switching equipment)

- Transmission lines (these include all subcomponents such as equipment used to connect central office to end users)

- Cabling (low capacity links)

Central offices and broadcasting stations are the only components of the communication system considered in this section.

4.6.1. Description of Communication System Components

As it was mentioned previously, only facilities are considered. A communication facility consists of a building (generic type is assumed in the methodology), central switching equipment (i.e., digital switches, anchored or unanchored), and back-up power supply (i.e. diesel generators or battery generators, anchored or unanchored) that may be needed to supply the requisite power to the center in case of loss of off-site power.

4.6.2. Definitions of Damage States

Communication facilities are susceptible to earthquake damage. A total of five damage states are defined for these components. These are none (DS1), slight/minor (DS2), moderate (DS3), extensive (DS4) and complete (DS5).

Slight/Minor Damage (DS2)

Slight damage, DS2 is defined by slight damage to the communication facility building, or inability of the center to provide services during a short period (few days) due to loss of electric power and backup power, if available.

Moderate Damage (DS3)

Moderate damage, DS3 is defined by moderate damage to the communication facility building, few digital switching boards being dislodged, or the central office being out of service for a few days due to loss of electric power (i.e., power failure) and backup power (typically due to overload), if available.

Extensive Damage (DS4)

Extensive damage, DS4 is defined by severe damage to the communication facility building resulting in limited access to facility, or by many digital switching boards being dislodged, resulting in malfunction.

Complete Damage (DS5)

Complete damage, DS5 is defined by complete damage to the communication facility building, or damage beyond repair to digital switching boards.

Part II

5. Casualties

In the loss assessment methodology there are four categories for casualties, from Level I to IV, depending on the injury classification scale.

5.1. Injury Severity Level I

Injuries requiring basic medical aid that could be administered by paraprofessionals; these types of injuries would require bandages or observation. Some examples are: a sprain, a severe cut requiring stitches, a minor burn (first degree or second degree on a small part of the body), or a bump on the head without loss of consciousness. Injuries of lesser severity that could be self treated are not estimated by HAZUS-MH MR2.

5.2. Injury Severity Level II

Injuries requiring a greater degree of medical care and use of medical technology, such as x-rays or surgery, but not expected to progress to a life threatening status. Some examples are third degree burns or second degree burns over large parts of the body, a bump on the head that causes loss of consciousness, fractured bone, dehydration or exposure.

5.3. Injury Severity Level III

Injuries that pose an immediate life threatening condition if not treated adequately and expeditiously. Some examples are: uncontrolled bleeding, punctured organ, other internal injuries, spinal column injuries, or crush syndrome.

5.4. Injury Severity Level IV

Instantaneously killed or mortally injured

Conclusion

This terminology guide contains definitions for the loss assessment analysis reports made by the Mid-America Earthquake Center for the FEMA Catastrophic Event Planning project. The main objective of this document is to help planners to understand engineering terms contained in the reports. In order to improve this document, comments and suggestions from users are very important to be considered in future versions.

Appendix VIII: Damage and Loss Maps

This appendix includes maps of direct damage and functionality loss to infrastructure as well as demographic data, induced damage, and social impacts. These maps are designed to support the scenario report provided to each state in the New Madrid Seismic Zone. A total of ten scenarios are represented in this appendix and are listed below:

1. New Madrid Seismic Zone M_w7.7 Event for the State of Alabama
2. East Tennessee Seismic Zone M_w5.9 Event for the State of Alabama
3. New Madrid Seismic Zone M_w7.7 Event for the State of Arkansas
4. New Madrid Seismic Zone M_w7.7 Event for the State of Illinois
5. New Madrid Seismic Zone M_w7.7 Event for the State of Indiana
6. Wabash Valley Seismic Zone M_w7.1 Event for the State of Indiana
7. New Madrid Seismic Zone M_w7.7 Event for the State of Kentucky
8. New Madrid Seismic Zone M_w7.7 Event for the State of Mississippi
9. New Madrid Seismic Zone M_w7.7 Event for the State of Missouri
10. New Madrid Seismic Zone M_w7.7 Event for the State of Tennessee

For more information on the scenarios employed, including hazard, inventory, and fragility components, please refer to the appropriate appendices. Additionally, a discussion of detailed results for each scenario represented in this appendix can be found in Appendix V.

Each scenario represented here has more than 30 maps showing impacts to various types of infrastructure and population groups. Though not all scenarios will have every map listed below, each scenario will contain a majority of the following types of damage and loss maps:

- Airport Damage
- Airport Functionality at Day 1
- Worst-Case Casualties[1]
- Communication Facility Damage
- Dam Inventory with Modified Mercalli Intensity
- Total Debris Generated
- Displaced Population
- Electric Power Facility Damage
- Emergency Operation Center (EOC) Damage
- Emergency Operation Center Functionality at Day 1
- Ferry Facility Damage
- Fire Station Damage
- Fire Station Functionality at Day 1
- Hazardous Materials Facility Inventory with Modified Mercalli Intensity
- Highway Bridge Functionality at Day 1
- Highway Bridge & Segment Damage

[1] This indicates the time of day where the greatest number of casualties occur

- Hospital Damage
- Hospital Functionality at Day 1
- Liquefaction Susceptibility
- Modified Mercalli Intensity
- Natural Gas Facility Damage with Major Transmission Pipelines
- Oil Facility Damage with Major Transmission Pipelines
- Peak Ground Acceleration (PGA)
- Police Station Damage
- Police Station Functionality at Day 1
- Total Population
- Port Facility Damage
- Potable Water Facility & Local Distribution Network Damage
- Prison Inventory with Modified Mercalli Intensity
- Railway Bridge & Segment Damage
- Railway Bridge Functionality at Day 1
- School Damage
- School Functionality at Day 1
- Waste Water Facility & Local Distribution Network Damage

All infrastructure damage maps represent the likelihood of damage for facilities in the at least moderate damage state. The definition of this damage state varies with the type of facility, and descriptions of these damage states can be found in Appendix VII. For additional information on these damage states, please refer to the HAZUS-MH MR2 Technical Manual. All infrastructure functionalities are displayed for the day after the earthquake, termed Day 1. Estimates of infrastructure functionality are available for various intervals after the event including Days 3, 7, 14, 30, and 90, though they are not illustrated in this report. The greatest number of facilities will be non-operational immediately after the earthquake, thus Day 1 functionality represents the greatest number of non-functioning facilities and the greatest reduction in services to affected populations. Finally, all maps include a table quantifying impacts to a set of critical counties in the state shown. These counties are closest to the source of seismic activity and are likely to experience the most significant impacts.

Airport Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	4	0	0
Cullman	9	0	0
Fayette	7	0	0
Franklin	2	0	0
Lamar	2	0	0
Lauderdale	4	0	0
Lawrence	5	0	0
Limestone	4	0	0
Marion	2	0	0
Morgan	6	0	0
Walker	4	0	0
Winston	6	0	0

Legend

Airport Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Rivers

US Routes

Interstates

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

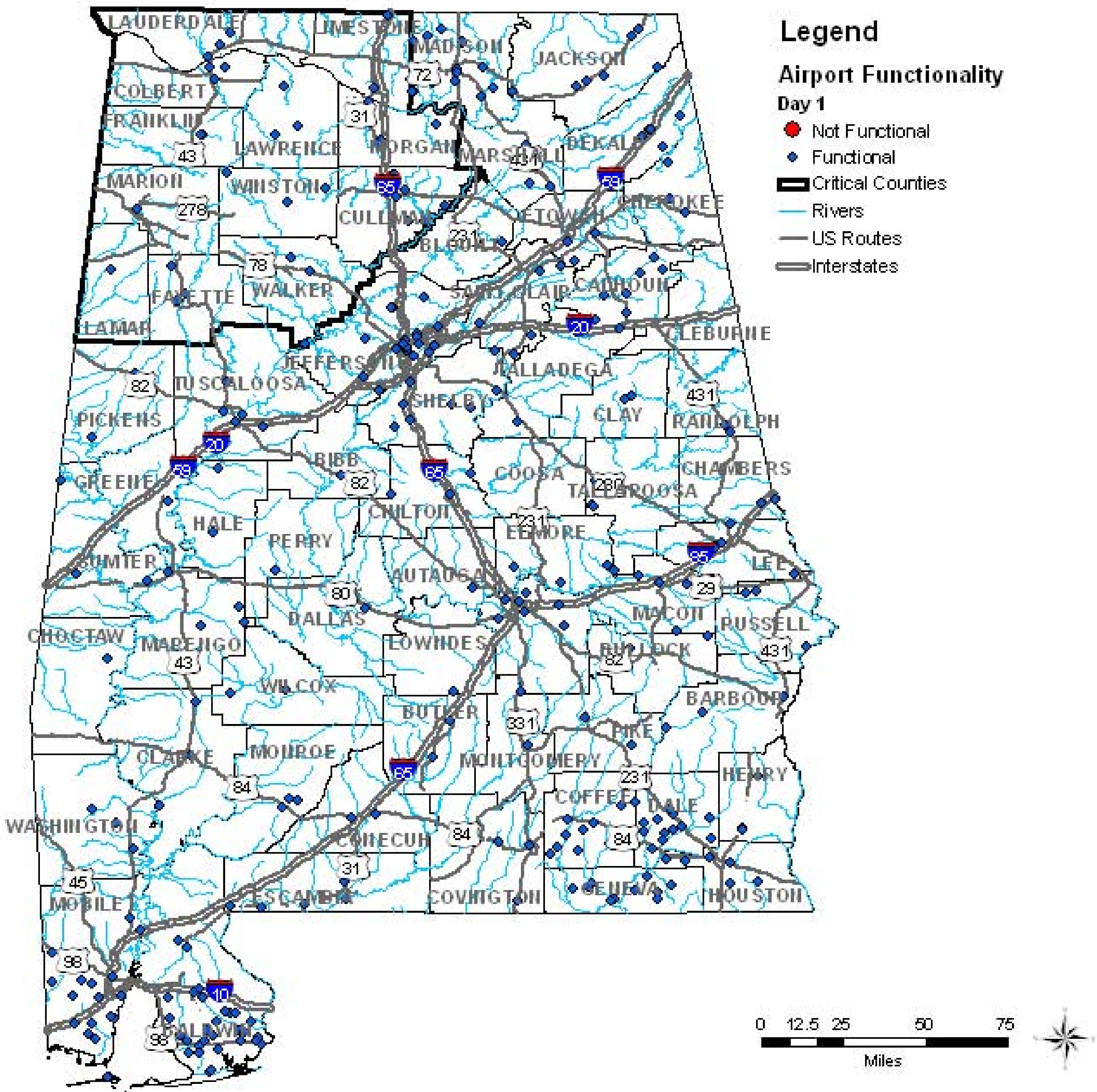
Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Airport Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Colbert	4	4
Cullman	9	9
Fayette	7	7
Franklin	2	2
Lamar	2	2
Lauderdale	4	4
Lawrence	5	5
Limestone	4	4
Marion	2	2
Morgan	6	6
Walker	4	4
Winston	6	6

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Worst Case Casualties - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Colbert	11	0	11
Cullman	2	0	2
Fayette	5	0	5
Franklin	4	0	4
Lamar	5	0	5
Lauderdale	21	0	21
Lawrence	1	0	1
Limestone	2	0	2
Marion	6	0	6
Morgan	2	0	2
Walker	3	0	3
Winston	5	0	5

Legend

Worst Case Casulaties

(5 PM)

- 0 - 1
- 1 - 2
- 2 - 4
- 4 - 12

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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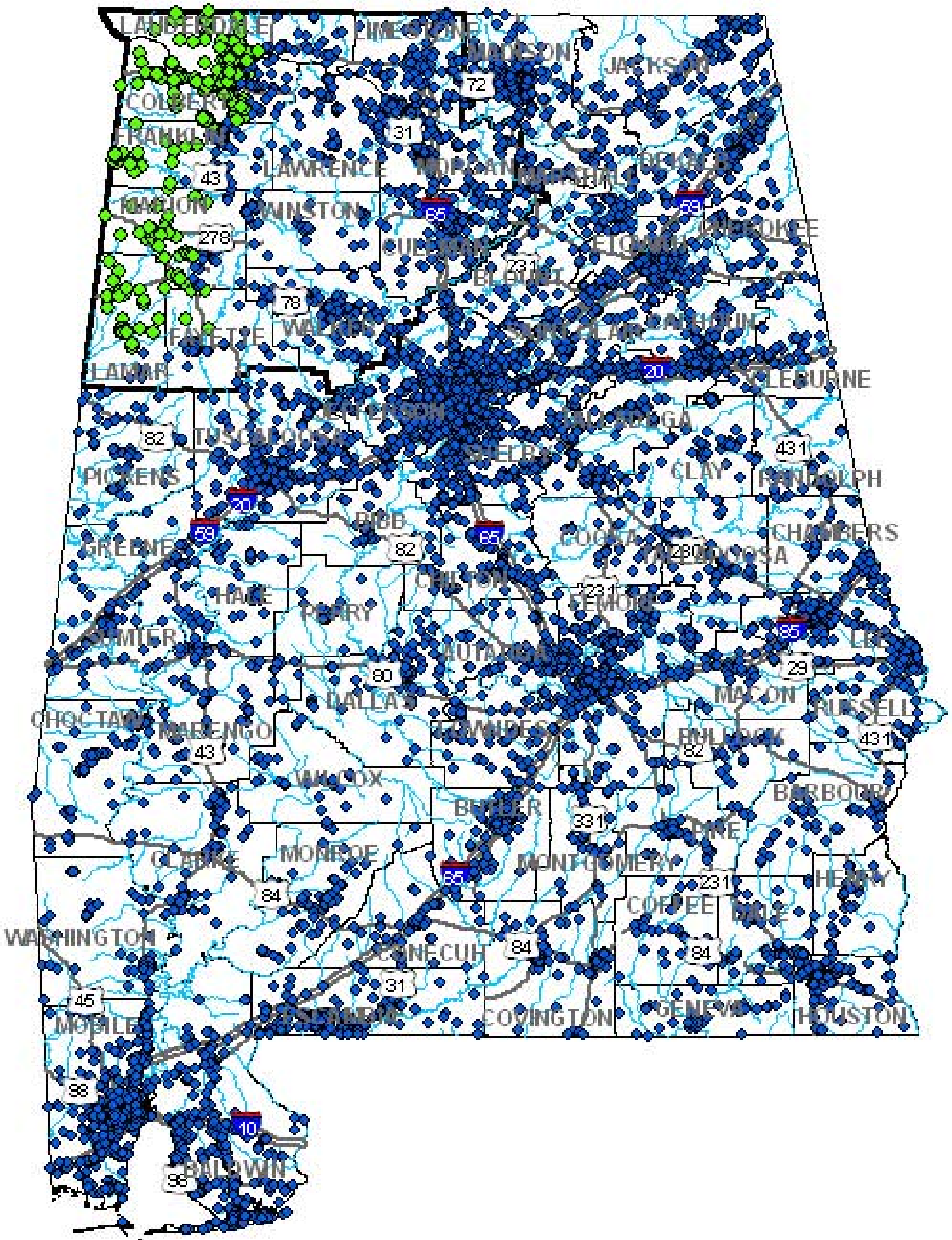
Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	315	0	0
Cullman	272	0	0
Fayette	52	0	0
Franklin	107	0	0
Lamar	50	0	0
Lauderdale	217	0	0
Lawrence	107	0	0
Limestone	184	0	0
Marion	131	0	0
Morgan	442	0	0
Walker	245	0	0
Winston	85	0	0

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

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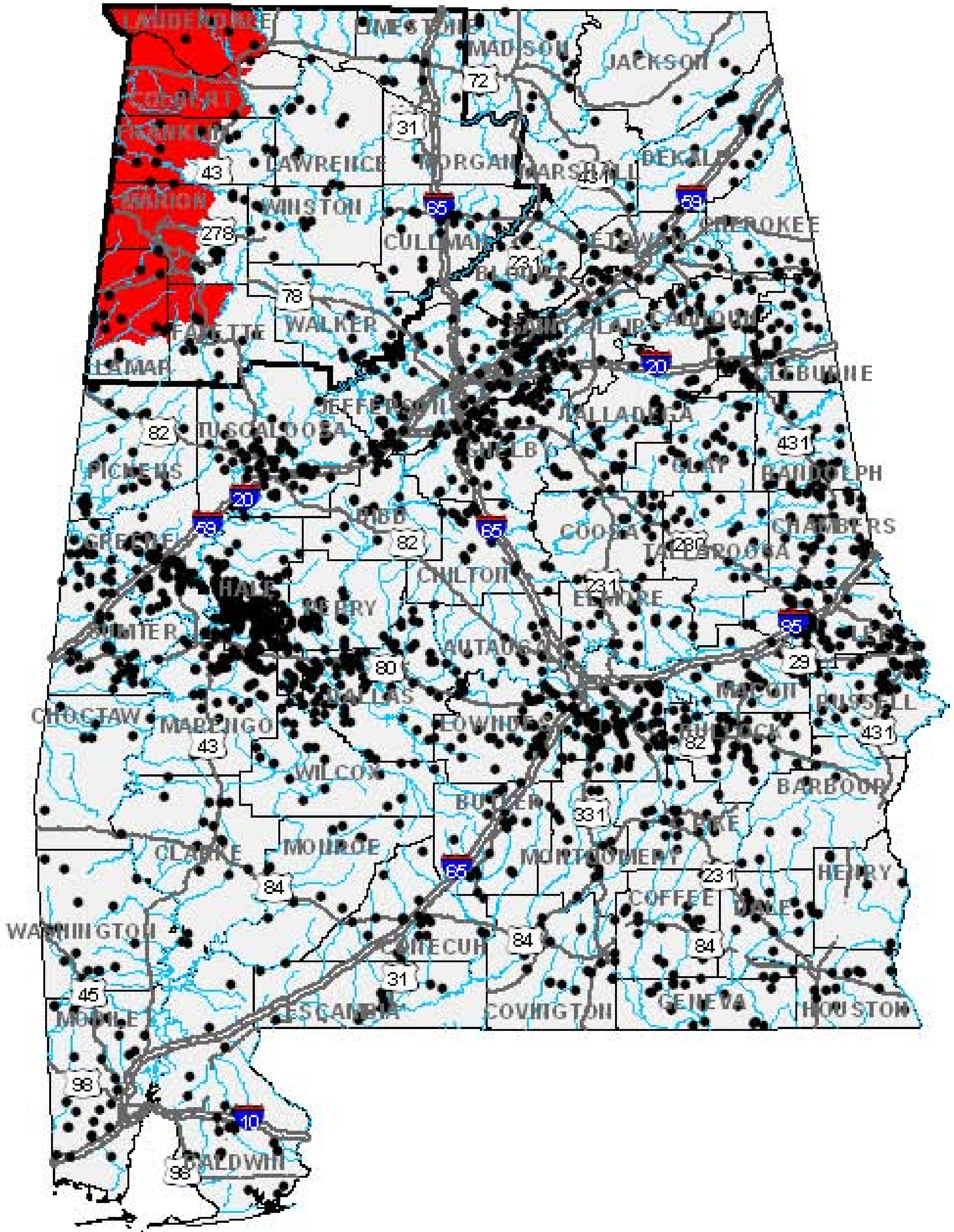
Dams - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	No. of Facilities
Colbert	4
Cullman	23
Fayette	14
Franklin	14
Lamar	13
Lauderdale	4
Lawrence	12
Limestone	12
Marion	13
Morgan	2
Walker	15
Winston	11

Legend

- Dams

MMI

- < VI
- VI
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75
Miles

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Displaced Population - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Displaced Residences	Displaced Population
Colbert	2	5
Cullman	0	0
Fayette	0	0
Franklin	0	1
Lamar	1	1
Lauderdale	5	13
Lawrence	0	0
Limestone	0	0
Marion	1	2
Morgan	0	0
Walker	0	0
Winston	1	1

Legend

Displaced Population

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 5
- 5 - 13

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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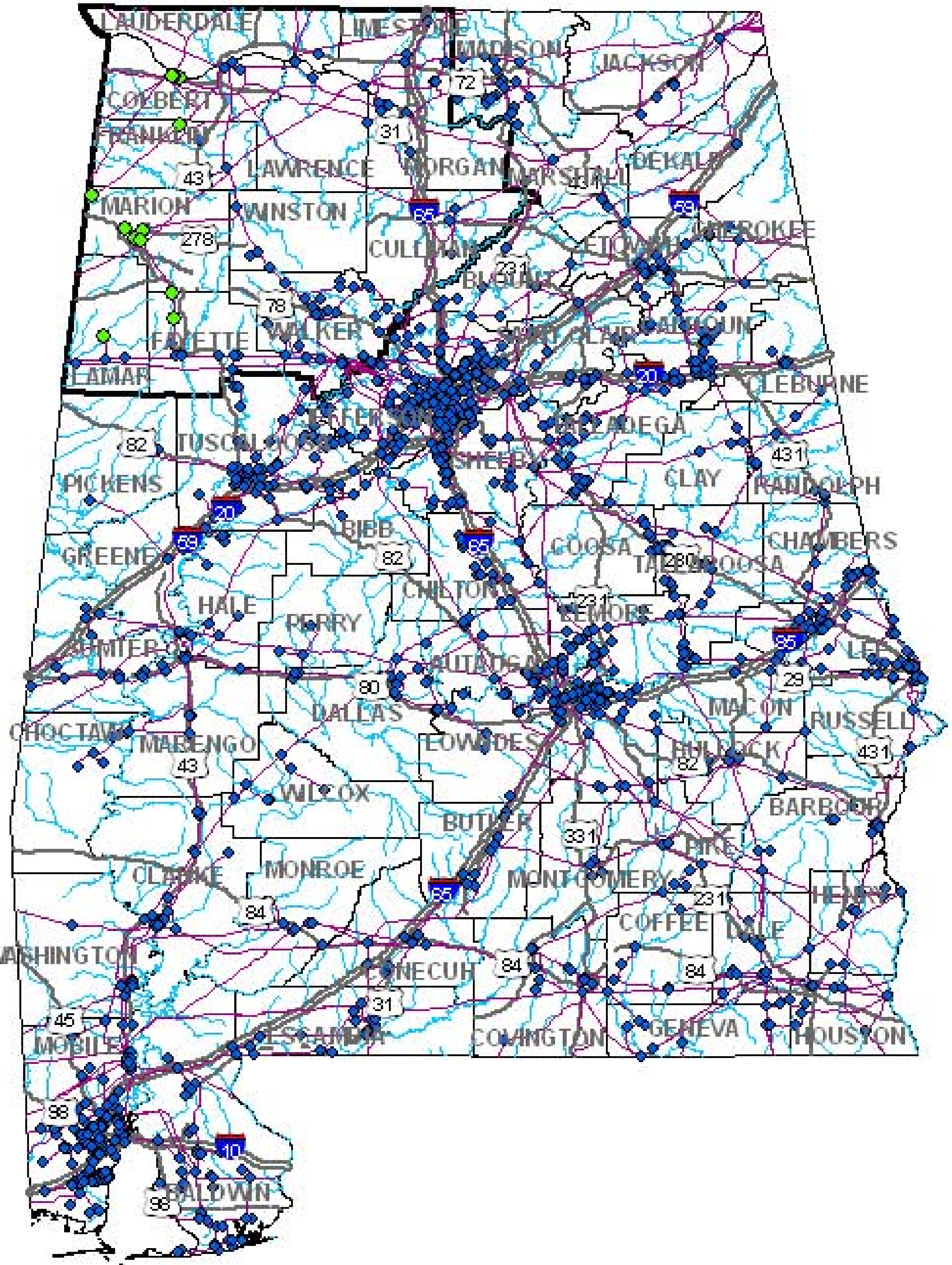
Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	7	0	0
Cullman	6	0	0
Fayette	11	0	0
Franklin	4	0	0
Lamar	4	0	0
Lauderdale	1	0	0
Lawrence	8	0	0
Limestone	9	0	0
Marion	5	0	0
Morgan	9	0	0
Walker	30	0	0
Winston	4	0	0

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Transmission Lines
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Cullman	1	0	0
Fayette	1	0	0
Walker	1	0	0
Colbert	0	0	0
Franklin	0	0	0
Lamar	0	0	0
Lauderdale	0	0	0
Lawrence	0	0	0
Limestone	0	0	0
Marion	0	0	0
Morgan	0	0	0
Winston	0	0	0

Legend

Emergency Operation Centers

At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Rivers

US Routes

Interstates

0 12.5 25 50 75

Miles

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Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

EOC Functionality - New Madrid Seismic Zone: M7.7 Event	March 2008

State of Alabama Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Cullman	1	1
Fayette	1	1
Walker	1	1
Colbert	0	0
Franklin	0	0
Lamar	0	0
Lauderdale	0	0
Lawrence	0	0
Limestone	0	0
Marion	0	0
Morgan	0	0
Winston	0	0

Legend

Emergency Operation Centers

Functionality at Day 1

- Not Functional
- Functional
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Ferry Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	20	0	0
Cullman	53	0	0
Fayette	13	0	0
Franklin	14	0	0
Lamar	10	0	0
Lauderdale	23	0	0
Lawrence	11	0	0
Limestone	20	0	0
Marion	12	0	0
Morgan	34	0	0
Walker	26	0	0
Winston	14	0	0

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Rivers

US Routes

Interstates

0 12.5 25 50 75

Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

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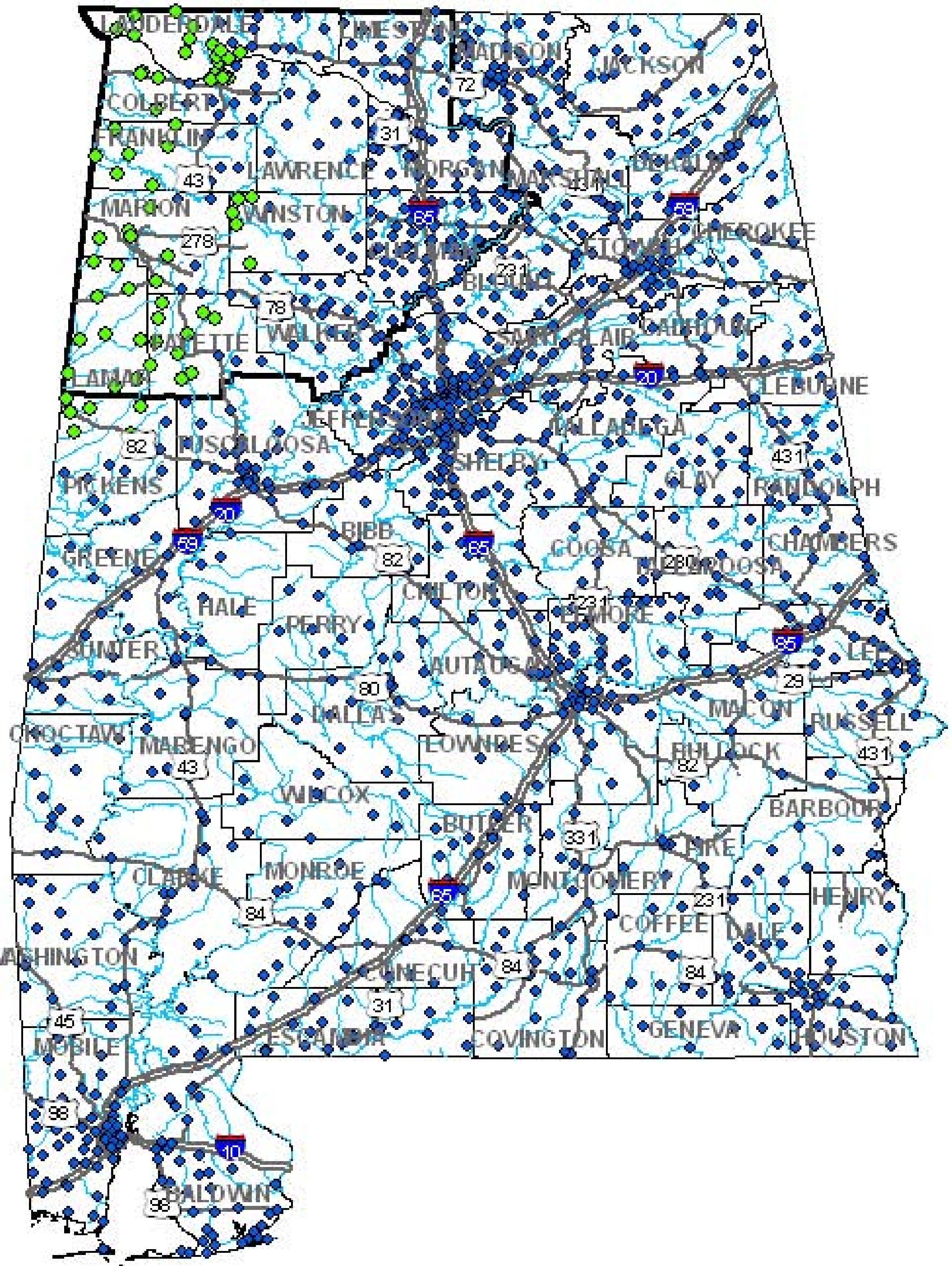
Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	20	0	0
Cullman	53	0	0
Fayette	13	0	0
Franklin	14	0	0
Lamar	10	0	0
Lauderdale	23	0	0
Lawrence	11	0	0
Limestone	20	0	0
Marion	12	0	0
Morgan	34	0	0
Walker	26	0	0
Winston	14	0	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Rivers
US Routes
Interstates

0 12.5 25 50 75
Miles

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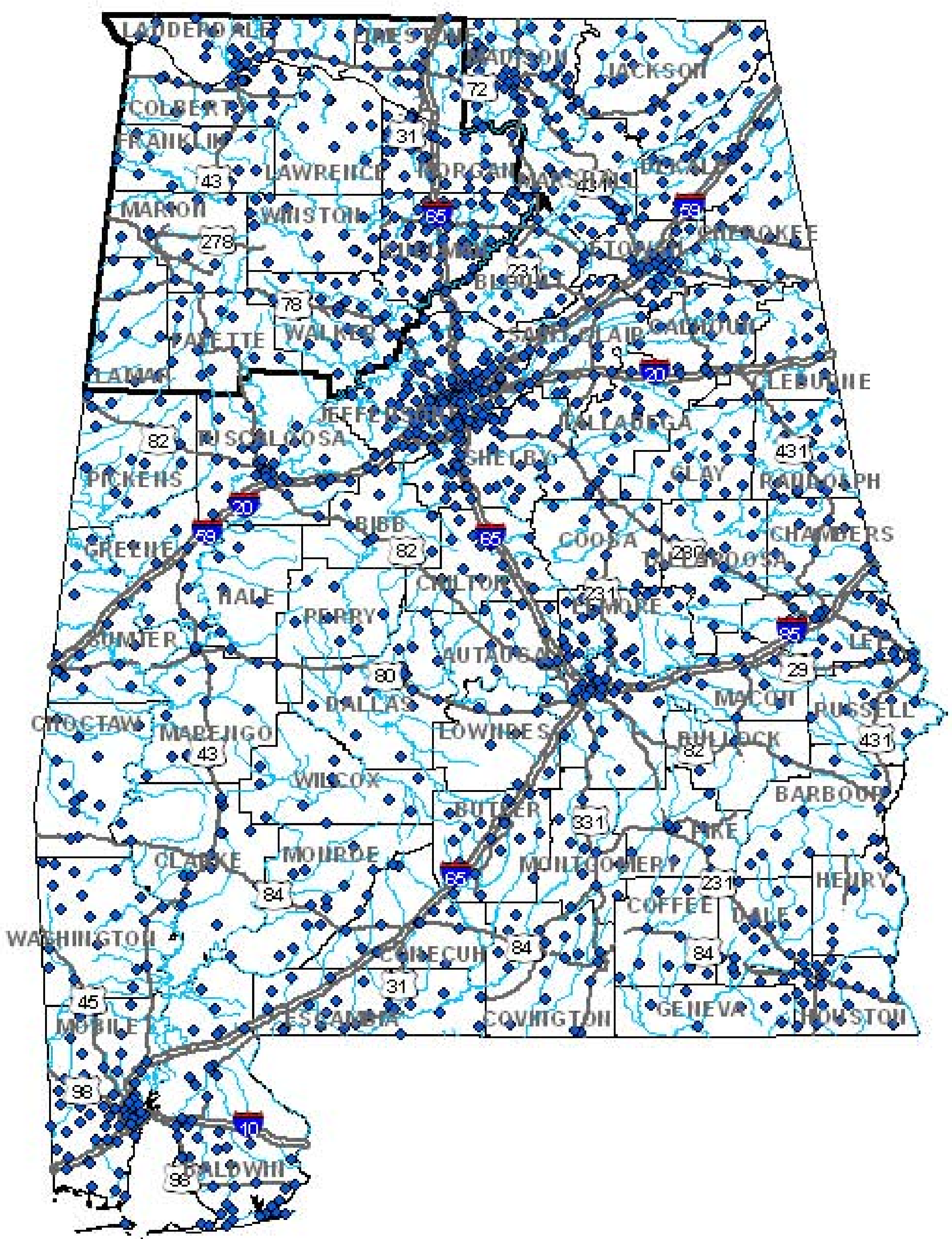
Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Fire Station Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama
Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Colbert	20	20
Cullman	53	53
Fayette	13	13
Franklin	14	14
Lamar	10	10
Lauderdale	23	23
Lawrence	11	11
Limestone	20	20
Marion	12	12
Morgan	34	34
Walker	26	26
Winston	14	14

Legend

Fire Station Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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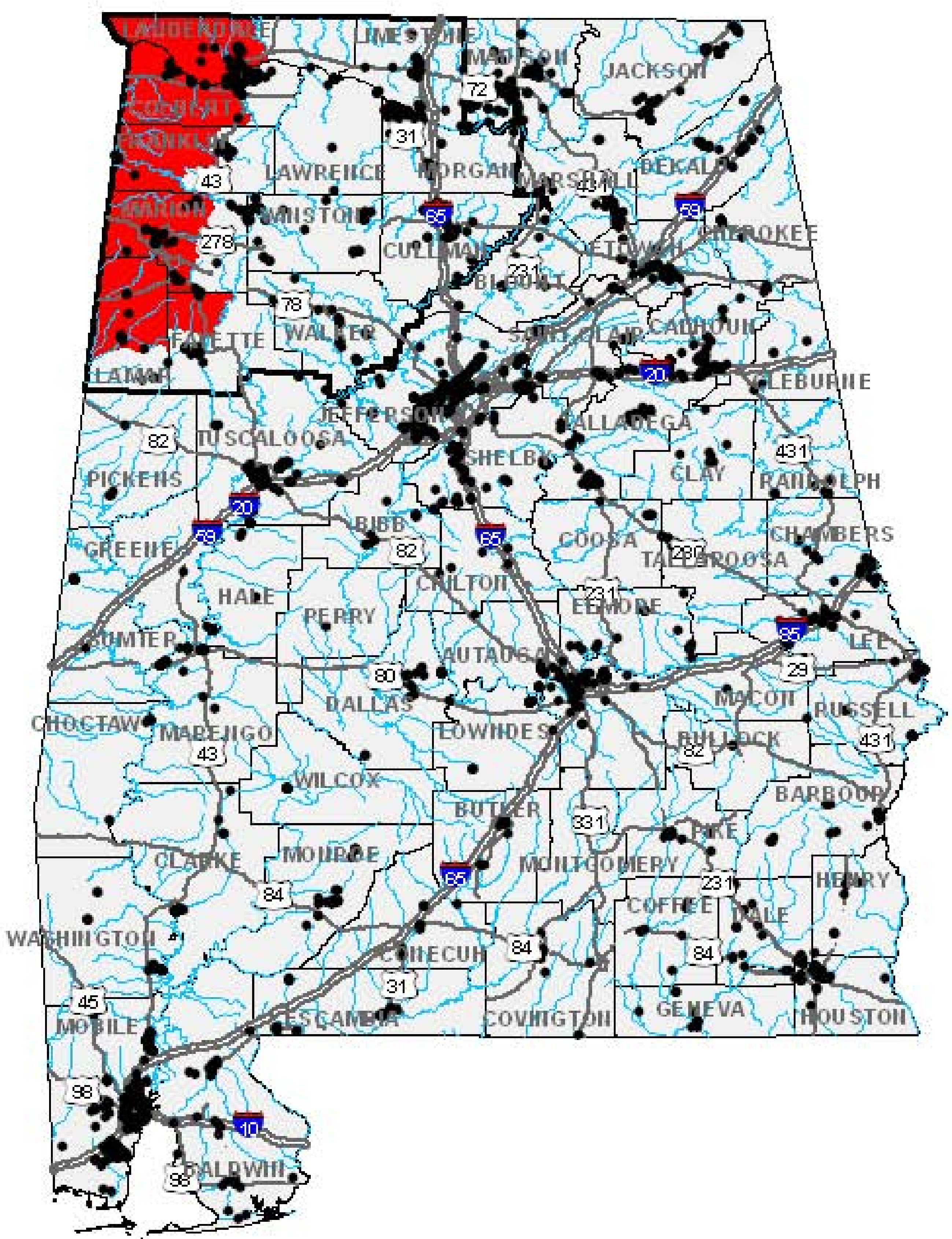
Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	No. of Facilities
Colbert	127
Cullman	77
Fayette	16
Franklin	22
Lamar	15
Lauderdale	26
Lawrence	23
Limestone	47
Marion	54
Morgan	193
Walker	32
Winston	47

Legend

- Hazardous Materials Facilities

MMI

- < VI
- VI
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75
Miles

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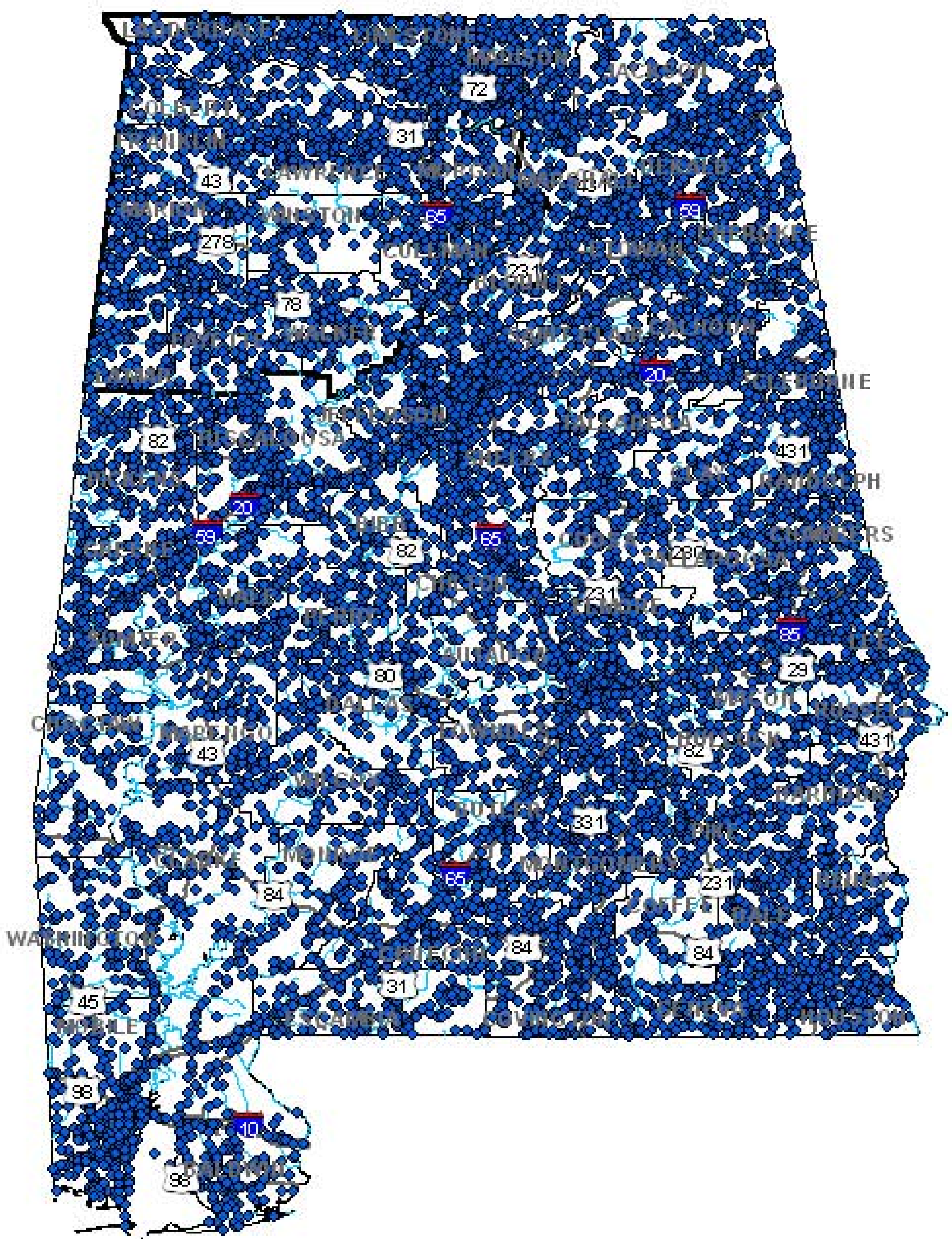
Highway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Colbert	131	131
Cullman	230	230
Fayette	162	162
Franklin	182	182
Lamar	172	172
Lauderdale	227	227
Lawrence	211	211
Limestone	299	299
Marion	232	232
Morgan	239	239
Walker	196	196
Winston	85	85

Legend

Highway Bridge Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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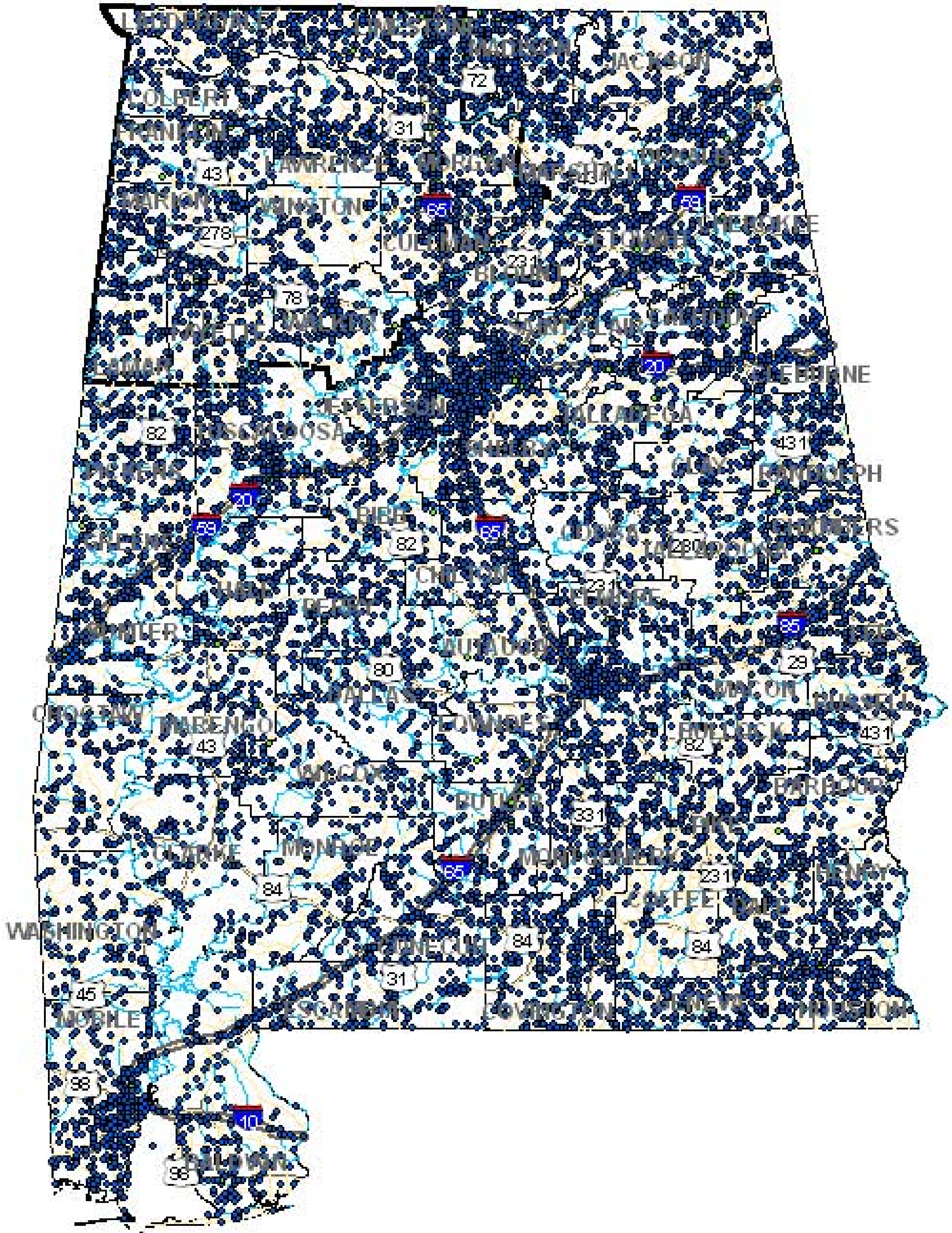
Highway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	131	0	0
Cullman	230	0	0
Fayette	162	0	0
Franklin	182	0	0
Lamar	172	0	0
Lauderdale	227	0	0
Lawrence	211	0	0
Limestone	299	0	0
Marion	232	0	0
Morgan	239	0	0
Walker	196	0	0
Winston	85	0	0

Legend

Highway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Highway Segment Damage

At Least Moderate

- Highly Unlikely
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Hospital Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	2	0	0
Cullman	2	0	0
Fayette	1	0	0
Franklin	2	0	0
Lauderdale	1	0	0
Lawrence	1	0	0
Limestone	1	0	0
Marion	2	0	0
Morgan	5	0	0
Walker	1	0	0
Winston	1	0	0
Lamar	0	0	0

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Hospital Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Colbert	2	2
Cullman	2	2
Fayette	1	1
Franklin	2	2
Lauderdale	1	1
Lawrence	1	1
Limestone	1	1
Marion	2	2
Morgan	5	5
Walker	1	1
Winston	1	1
Lamar	0	0

Legend

Hospital Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Minimum Susceptibility	Maximum Susceptibility
Colbert	Unknown	Unknown
Cullman	Unknown	Unknown
Fayette	Unknown	Unknown
Franklin	Unknown	Unknown
Lamar	Unknown	Unknown
Lauderdale	Unknown	None
Lawrence	Unknown	Unknown
Limestone	Unknown	Unknown
Marion	Unknown	Unknown
Morgan	Unknown	Unknown
Walker	Unknown	Unknown
Winston	Unknown	Unknown

Legend

Liquefaction Susceptibility
- Unknown
- None

Major Cities
- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Critical Counties
- Rivers
- US Routes
- Interstates

0 2.5 5 10 15
Miles

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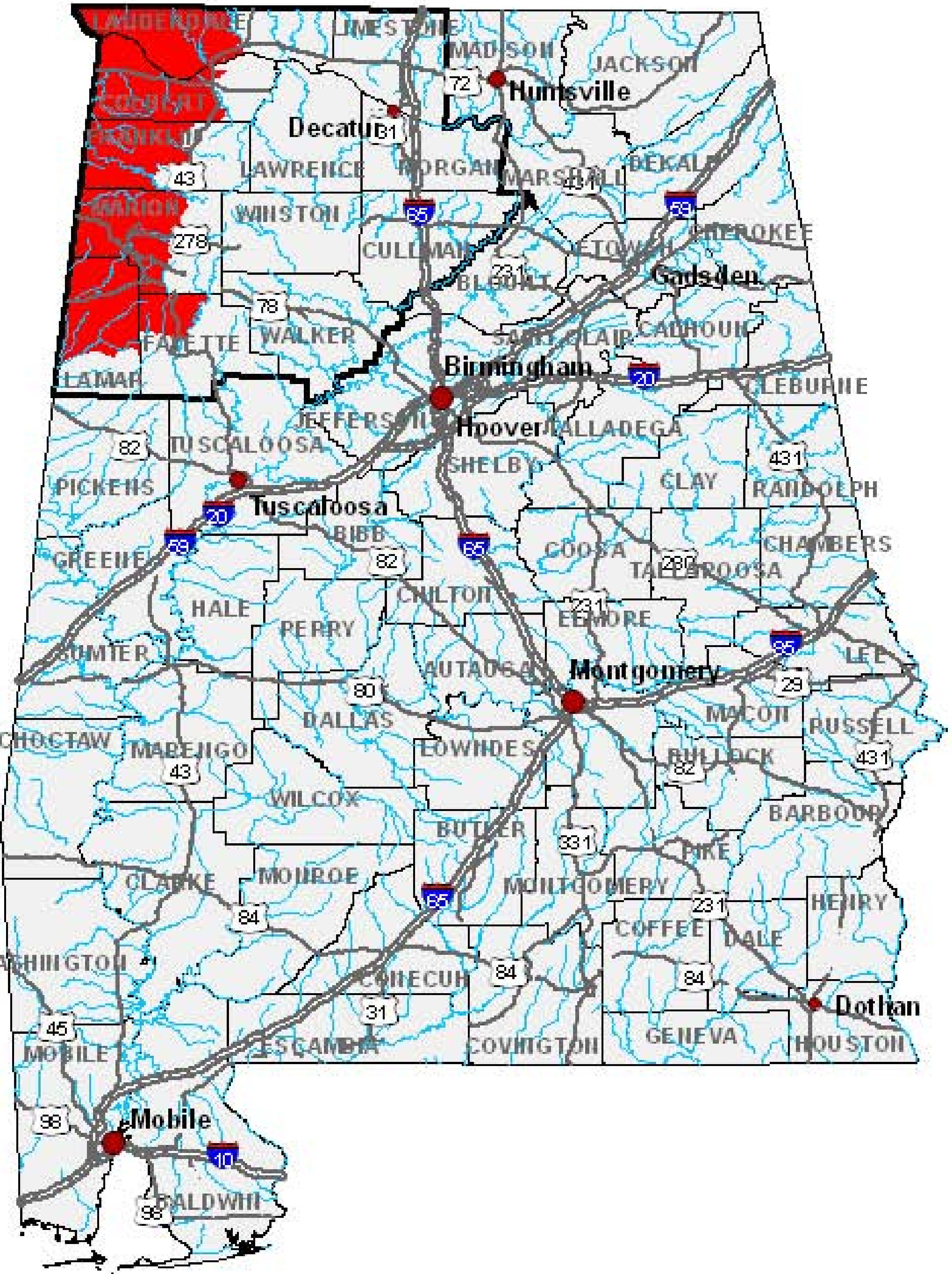
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Max. MMI
Colbert	VI
Cullman	< VI
Fayette	VI
Franklin	VI
Lamar	VI
Lauderdale	VI
Lawrence	< VI
Limestone	< VI
Marion	VI
Morgan	< VI
Walker	< VI
Winston	< VI

Legend

Modified Mercalli Intensity (MMI)

- < VI
- VI

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Natural Gas Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	25	0	0
Cullman	1	0	0
Fayette	3	0	0
Franklin	2	0	0
Lamar	1	0	0
Lauderdale	1	0	0
Lawrence	6	0	0
Limestone	10	0	0
Marion	2	0	0
Morgan	4	0	0
Walker	5	0	0
Winston	0	0	0

Legend

Natural Gas Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Transmission Lines
Critical Counties
Rivers
US Routes
Interstates

0 12.5 25 50 75
Miles

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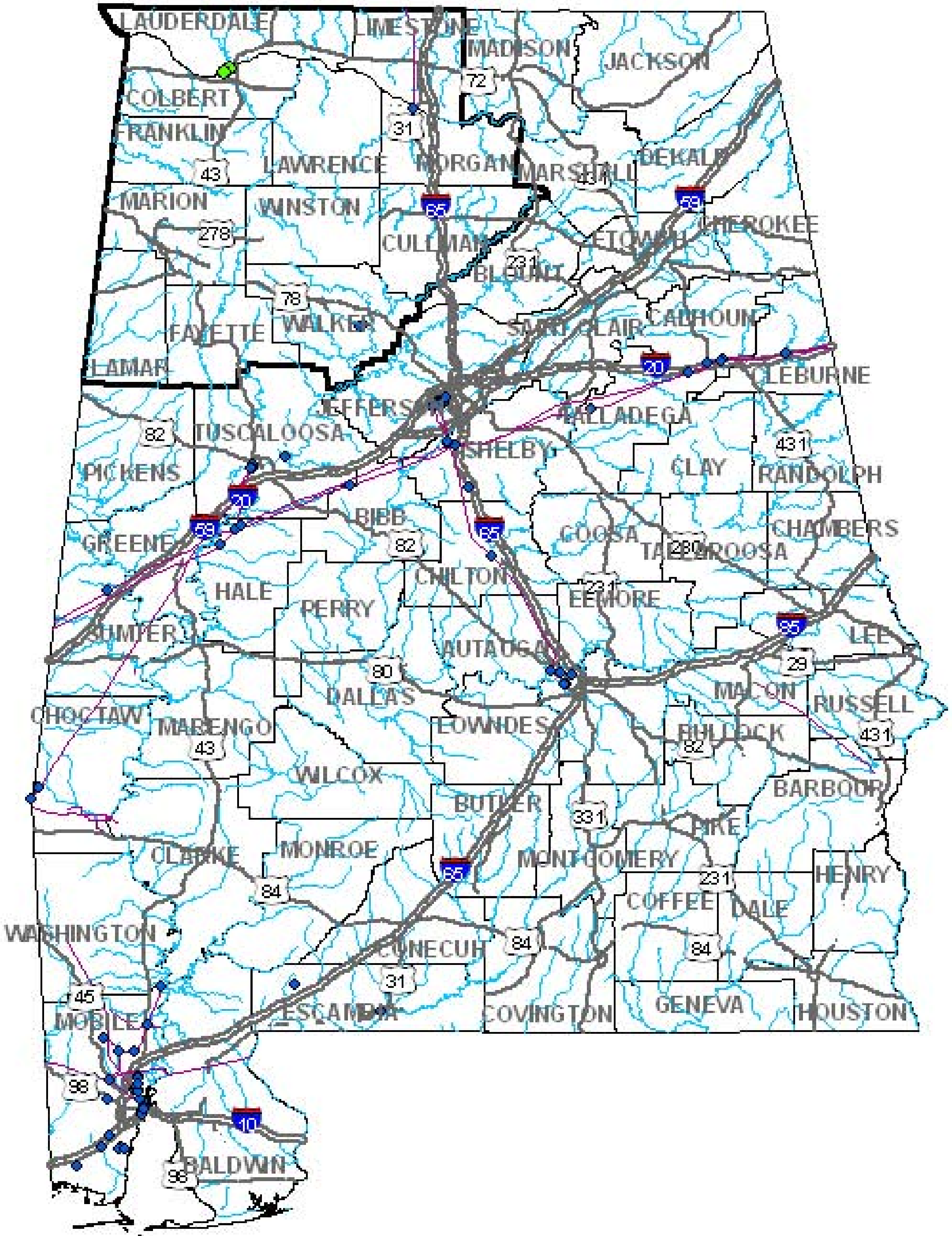
Oil Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	2	0	0
Morgan	1	0	0
Walker	2	0	0
Cullman	0	0	0
Fayette	0	0	0
Franklin	0	0	0
Lamar	0	0	0
Lauderdale	0	0	0
Lawrence	0	0	0
Limestone	0	0	0
Marion	0	0	0
Winston	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Transmission Lines
Critical Counties
Rivers
US Routes
Interstates

0 12.5 25 50 75
Miles

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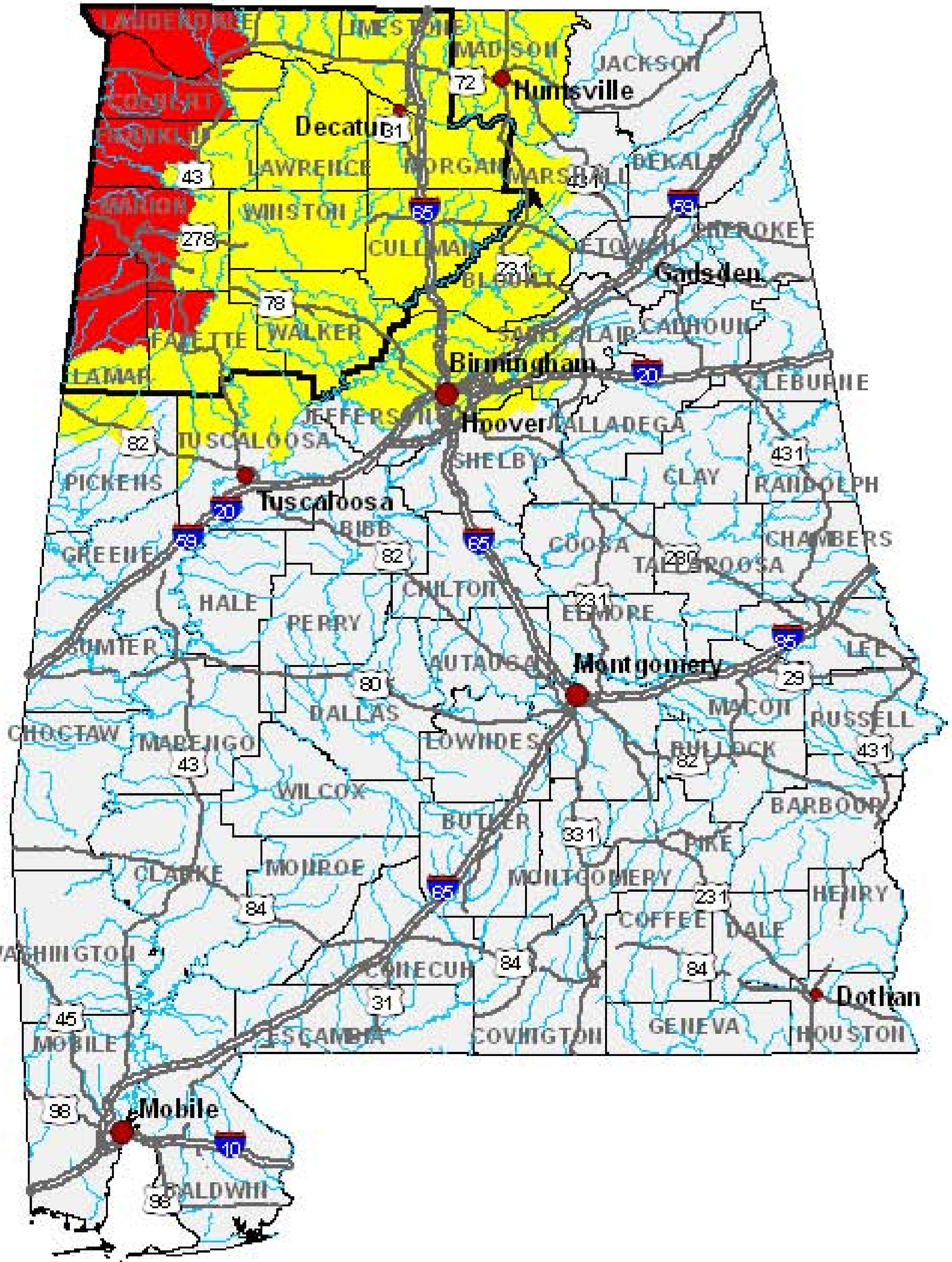
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Min. PGA	Max. PGA
Colbert	0.07	0.15
Cullman	0.07	0.07
Fayette	0.07	0.15
Franklin	0.07	0.15
Lamar	0.07	0.15
Lauderdale	0.07	0.15
Lawrence	0.07	0.07
Limestone	0.07	0.07
Marion	0.07	0.15
Morgan	0.07	0.07
Walker	0.07	0.07
Winston	0.07	0.07

Legend

PGA (g)

- 0.05 - 0.07
- 0.07 - 0.1
- 0.1 - 0.15

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Police Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	9	0	0
Cullman	5	0	0
Fayette	3	0	0
Franklin	5	0	0
Lamar	5	0	0
Lauderdale	9	0	0
Lawrence	6	0	0
Limestone	5	0	0
Marion	8	0	0
Morgan	9	0	0
Walker	9	0	0
Winston	5	0	0

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Rivers

US Routes

Interstates

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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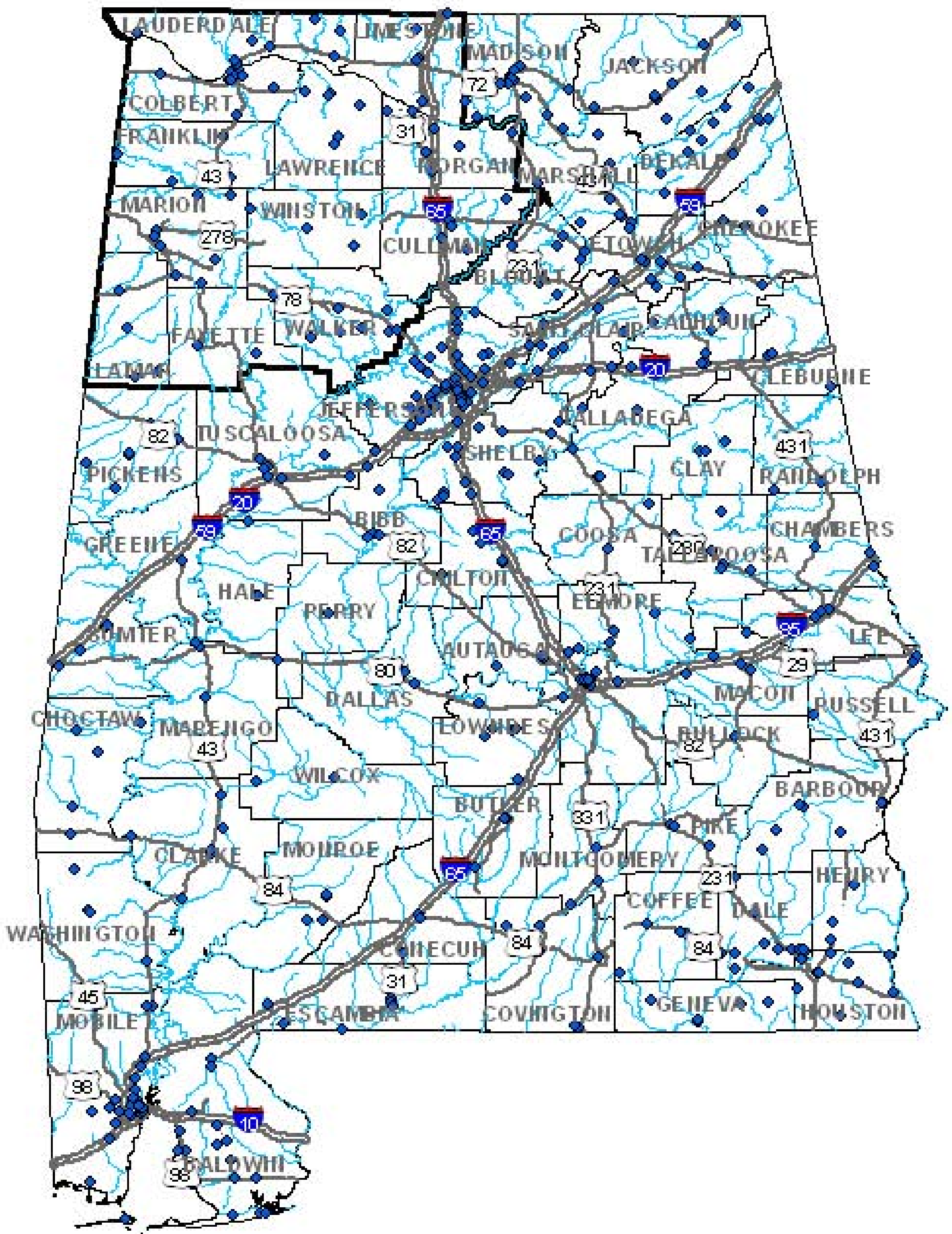
Police Station Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Colbert	9	9
Cullman	5	5
Fayette	3	3
Franklin	5	5
Lamar	5	5
Lauderdale	9	9
Lawrence	6	6
Limestone	5	5
Marion	8	8
Morgan	9	9
Walker	9	9
Winston	5	5

Legend

Police Station Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

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Port Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	8	0	0
Lauderdale	10	0	0
Lawrence	1	0	0
Limestone	3	0	0
Morgan	15	0	0
Walker	8	0	0
Cullman	0	0	0
Fayette	0	0	0
Franklin	0	0	0
Lamar	0	0	0
Marion	0	0	0
Winston	0	0	0

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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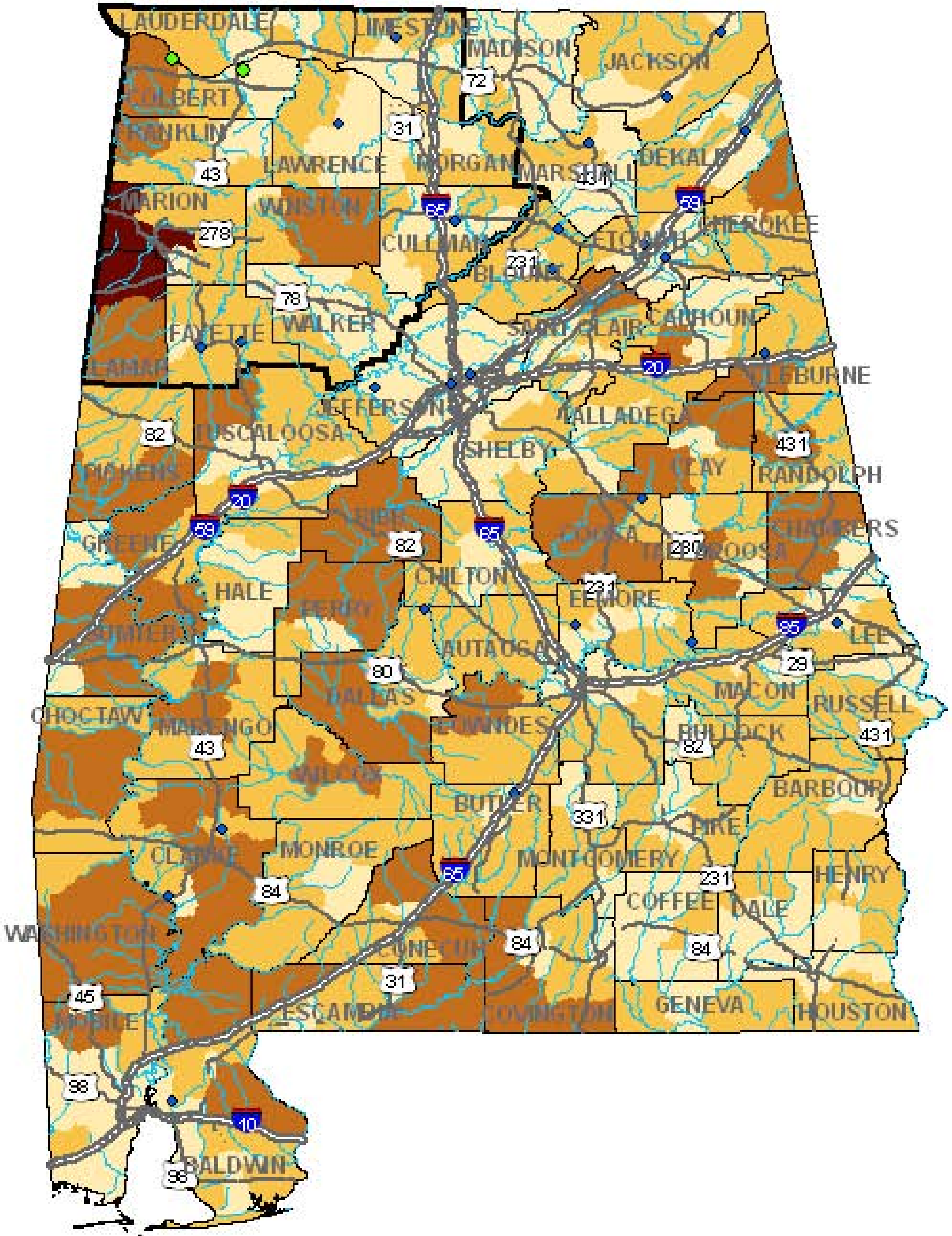
Potable Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	2	0	0
Cullman	1	0	0
Fayette	2	0	0
Lawrence	1	0	0
Limestone	1	0	0
Franklin	0	0	0
Lamar	0	0	0
Lauderdale	0	0	0
Marion	0	0	0
Morgan	0	0	0
Walker	0	0	0
Winston	0	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Potable Water Distribution Lines

No. of Leaks

- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 17
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75
Miles

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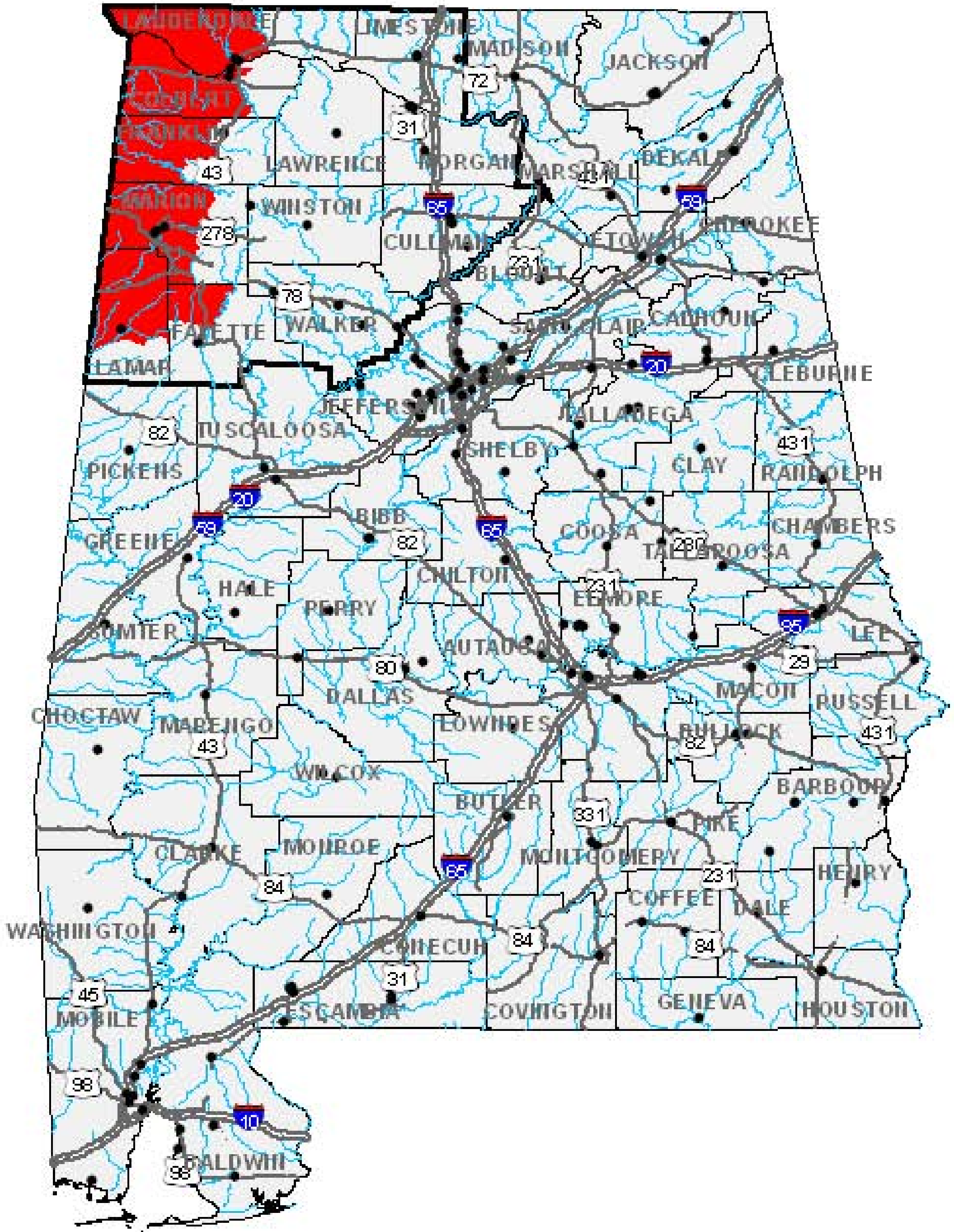
Prisons - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	No. of Facilities
Colbert	2
Cullman	4
Fayette	1
Franklin	2
Lamar	1
Lauderdale	2
Lawrence	1
Limestone	3
Marion	3
Morgan	4
Walker	5
Winston	2

Legend

- Prisons

MMI

- < VI
- VI
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Railway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Colbert	2	2
Cullman	6	6
Franklin	1	1
Limestone	3	3
Marion	2	2
Walker	4	4
Winston	2	2
Fayette	0	0
Lamar	0	0
Lauderdale	0	0
Lawrence	0	0
Morgan	0	0

Legend

Railway Bridge Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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Railway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	2	0	0
Cullman	6	0	0
Franklin	1	0	0
Limestone	3	0	0
Marion	2	0	0
Walker	4	0	0
Winston	2	0	0
Fayette	0	0	0
Lamar	0	0	0
Lauderdale	0	0	0
Lawrence	0	0	0
Morgan	0	0	0

Legend

Railway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Railway Segment Damage

At Least Moderate

- Highly Unlikely
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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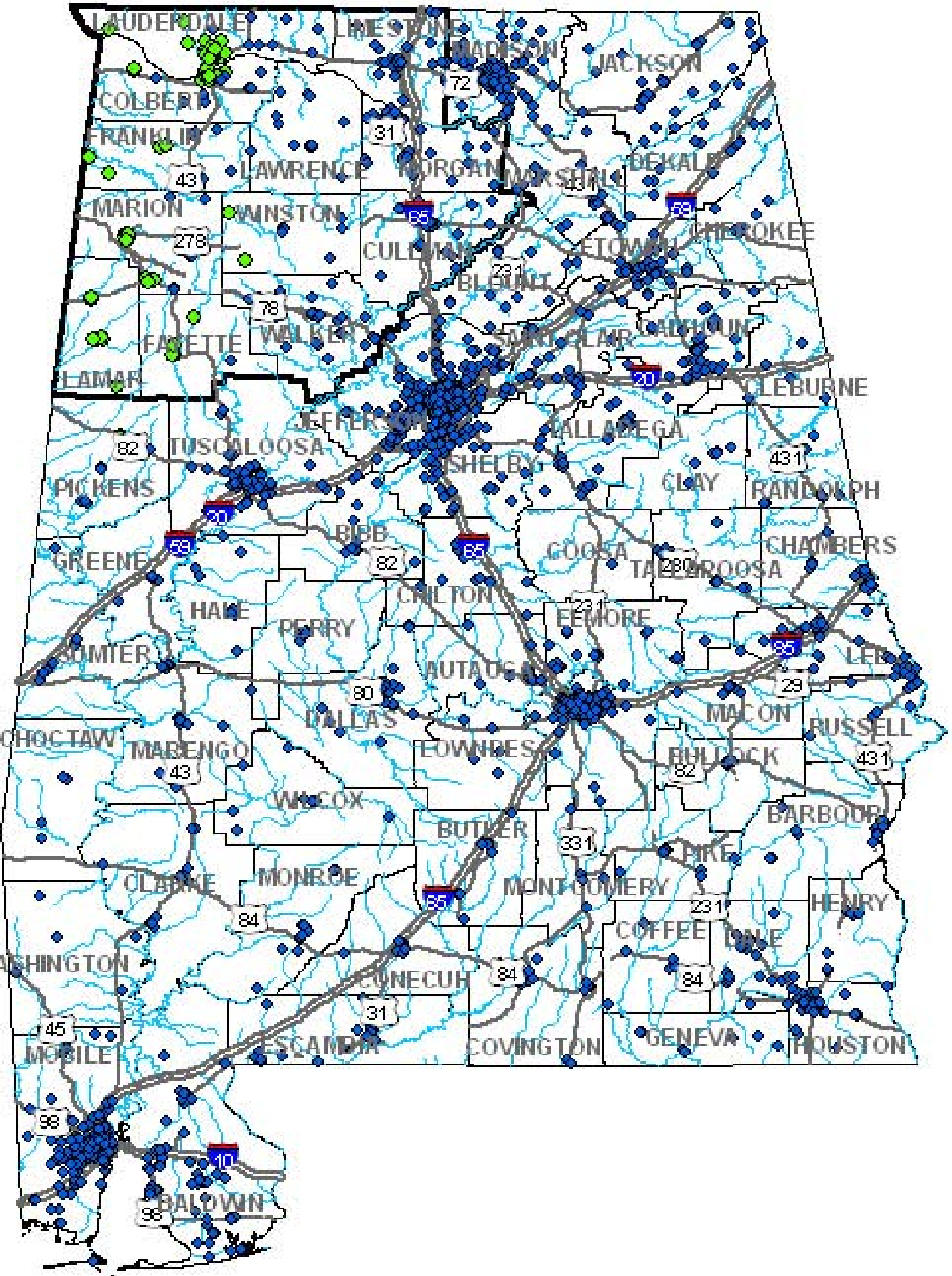
School Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	26	0	0
Cullman	37	0	0
Fayette	7	0	0
Franklin	13	0	0
Lamar	7	0	0
Lauderdale	28	0	0
Lawrence	16	0	0
Limestone	26	0	0
Marion	18	0	0
Morgan	46	0	0
Walker	33	0	0
Winston	13	0	0

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Rivers

US Routes

Interstates

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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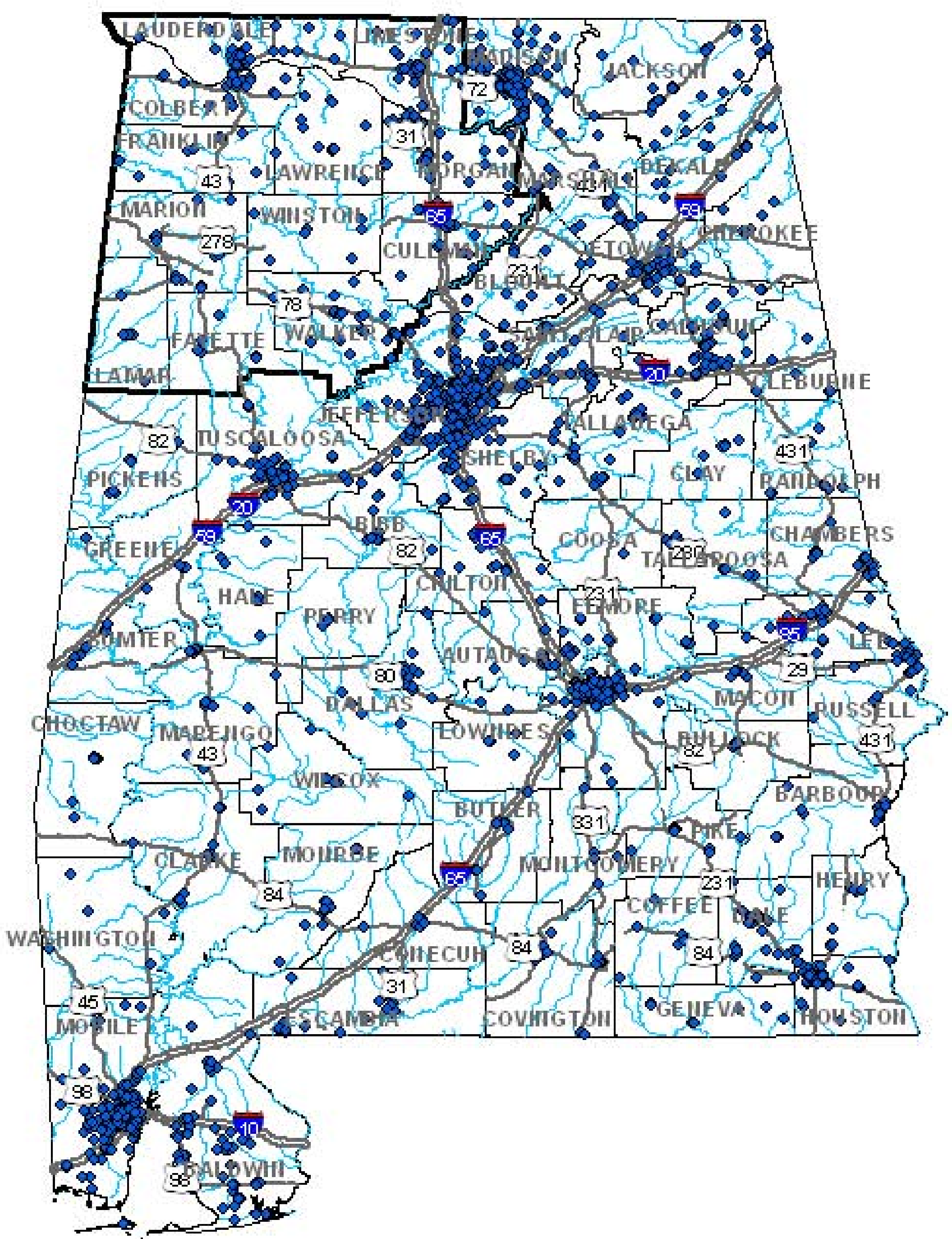
School Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	No. of Functional Facilities	Total No. of Facilities
Colbert	26	26
Cullman	37	37
Fayette	7	7
Franklin	13	13
Lamar	7	7
Lauderdale	28	28
Lawrence	16	16
Limestone	26	26
Marion	18	18
Morgan	46	46
Walker	33	33
Winston	13	13

Legend

School Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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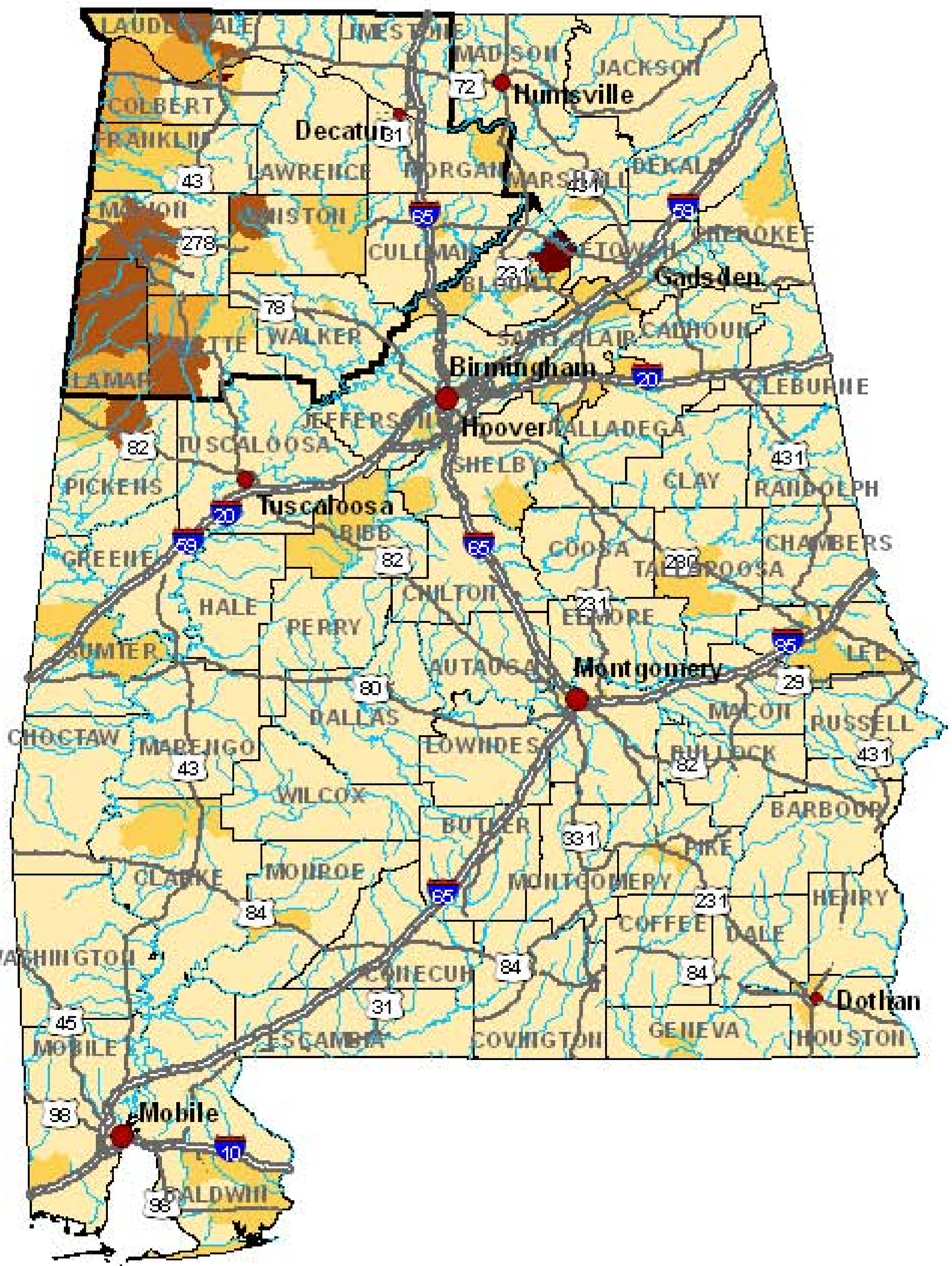
Total Debris - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Brick/ Wood (Tons)	Concrete/ Steel (Tons)	Total Debris (Tons)
Colbert	6,055	2,482	8,538
Cullman	852	155	1,007
Fayette	2,610	1,105	3,715
Franklin	1,720	580	2,301
Lamar	2,779	1,038	3,817
Lauderdale	10,357	4,161	14,517
Lawrence	342	54	396
Limestone	574	93	667
Marion	2,963	1,163	4,126
Morgan	1,140	220	1,359
Walker	828	151	979
Winston	2,505	1,003	3,509

Legend

Total Debris

(Tons)

- 0 - 100
- 101 - 500
- 501 - 1,000
- 1,001 - 3,000
- 3,000 - 17,100

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

Critical Counties

Rivers

US Routes

Interstates

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

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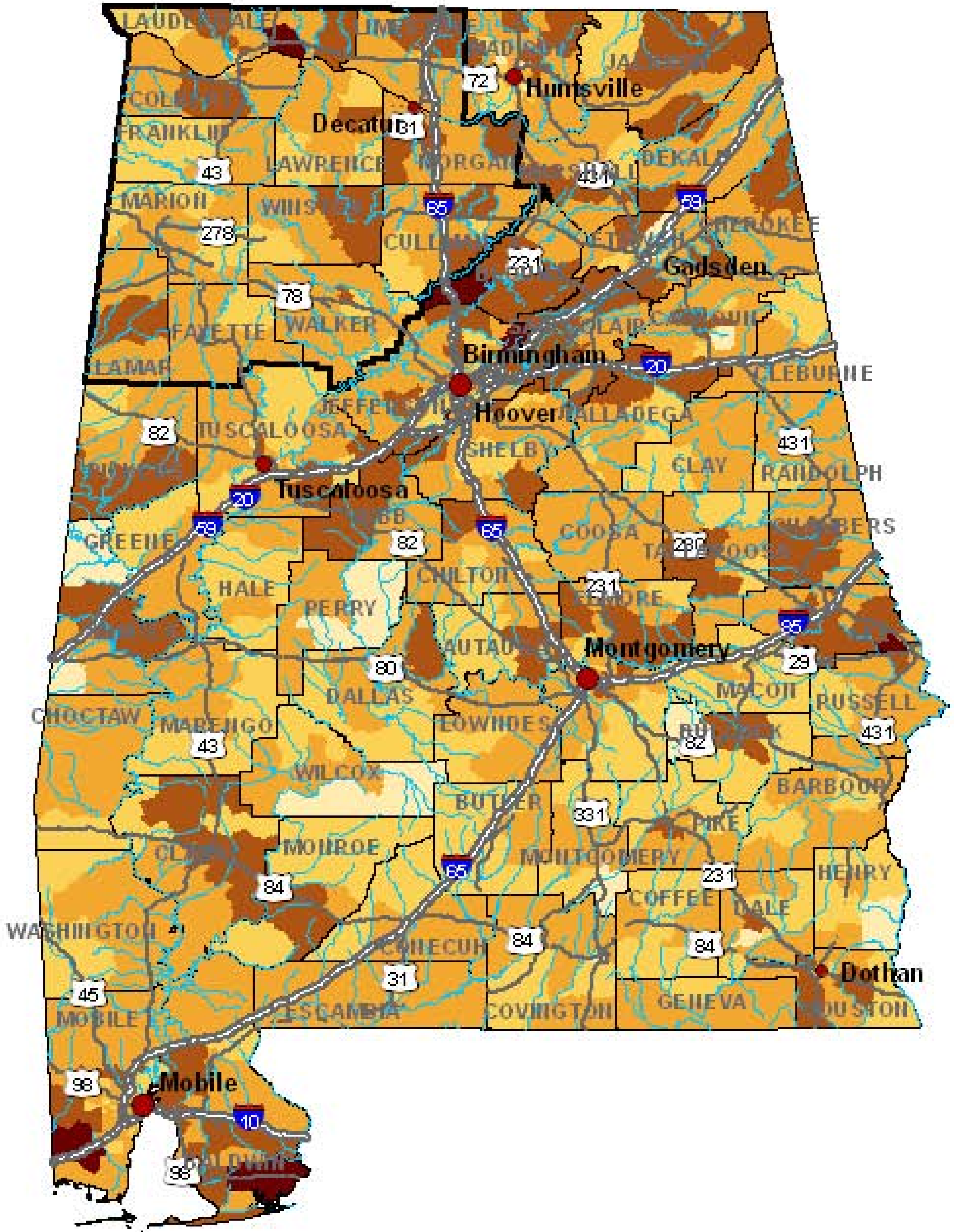
Total Population (2000) - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Population
Colbert	54,984
Cullman	77,483
Fayette	18,495
Franklin	35,889
Lamar	15,904
Lauderdale	87,966
Lawrence	38,789
Limestone	73,771
Marion	31,214
Morgan	111,064
Walker	74,793
Winston	24,843

Legend

Total Population (2000)

- 0 - 1,500
- 1,501 - 3,000
- 3,001 - 6,000
- 6,001 - 10,000
- 10,001 - 14,710

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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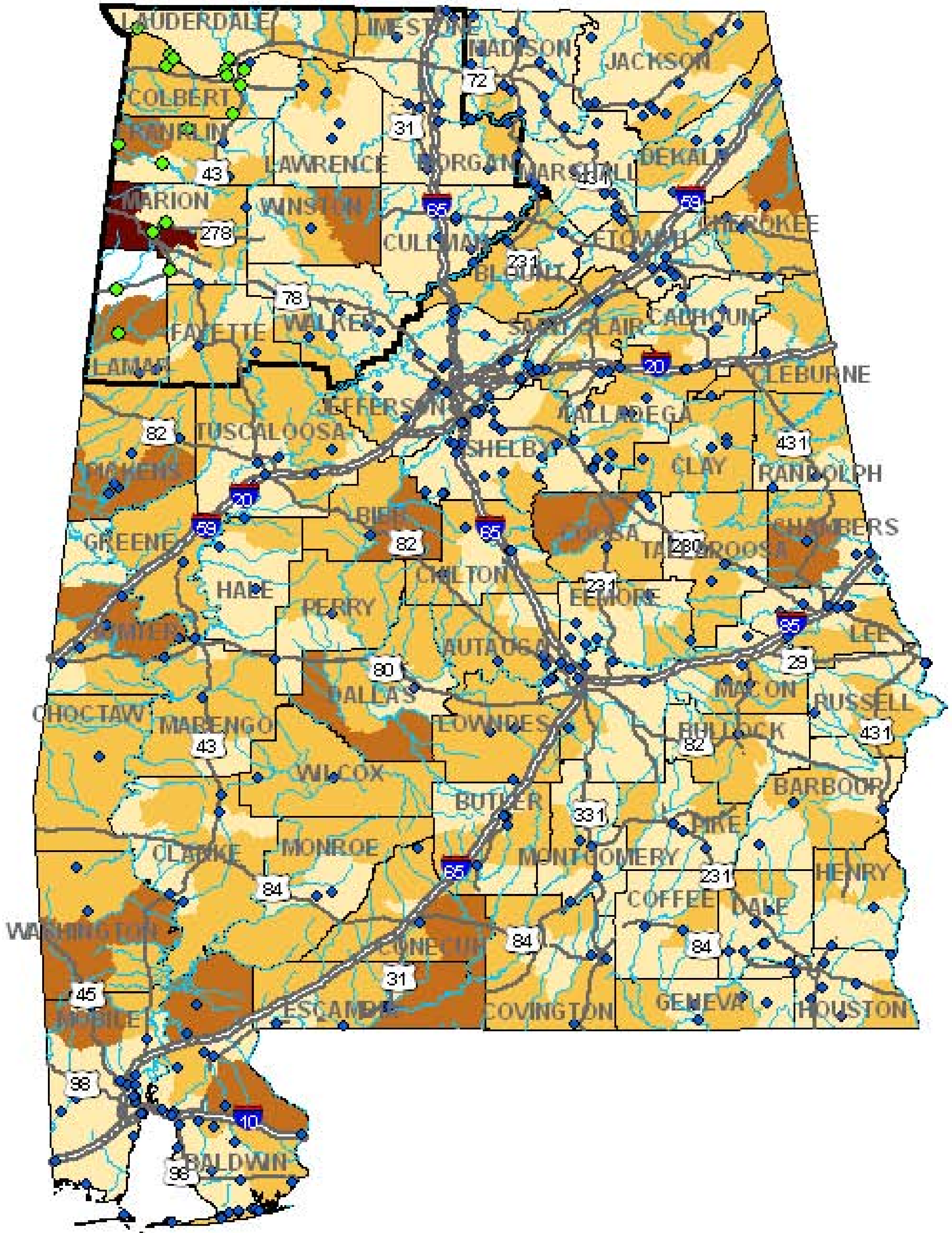
Waste Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Alabama Critical Counties (12)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Colbert	10	0	0
Cullman	9	0	0
Fayette	2	0	0
Franklin	5	0	0
Lamar	5	0	0
Lauderdale	2	0	0
Lawrence	4	0	0
Limestone	5	0	0
Marion	5	0	0
Morgan	8	0	0
Walker	7	0	0
Winston	1	0	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Waste Water Distribution Lines

No. of Leaks

- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 13
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75

Miles

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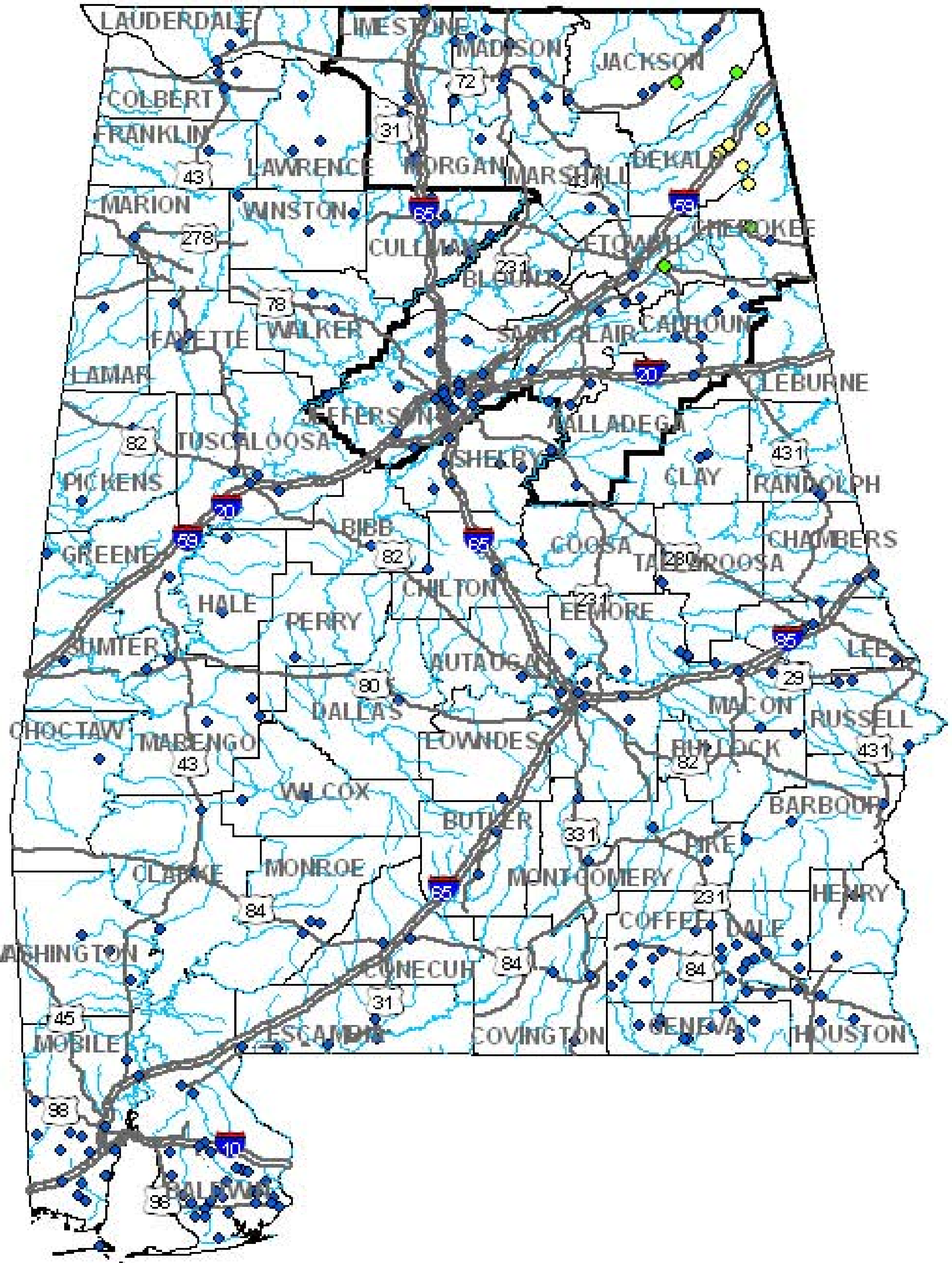
Airport Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	2	0	0
Calhoun	12	0	0
Cherokee	5	0	0
Dekalb	7	0	0
Etowah	4	0	0
Jackson	10	0	0
Jefferson	24	0	0
Limestone	4	0	0
Madison	24	0	0
Marshall	5	0	0
Morgan	6	0	0
Saint Clair	8	0	0
Talladega	4	0	0

Legend

Airport Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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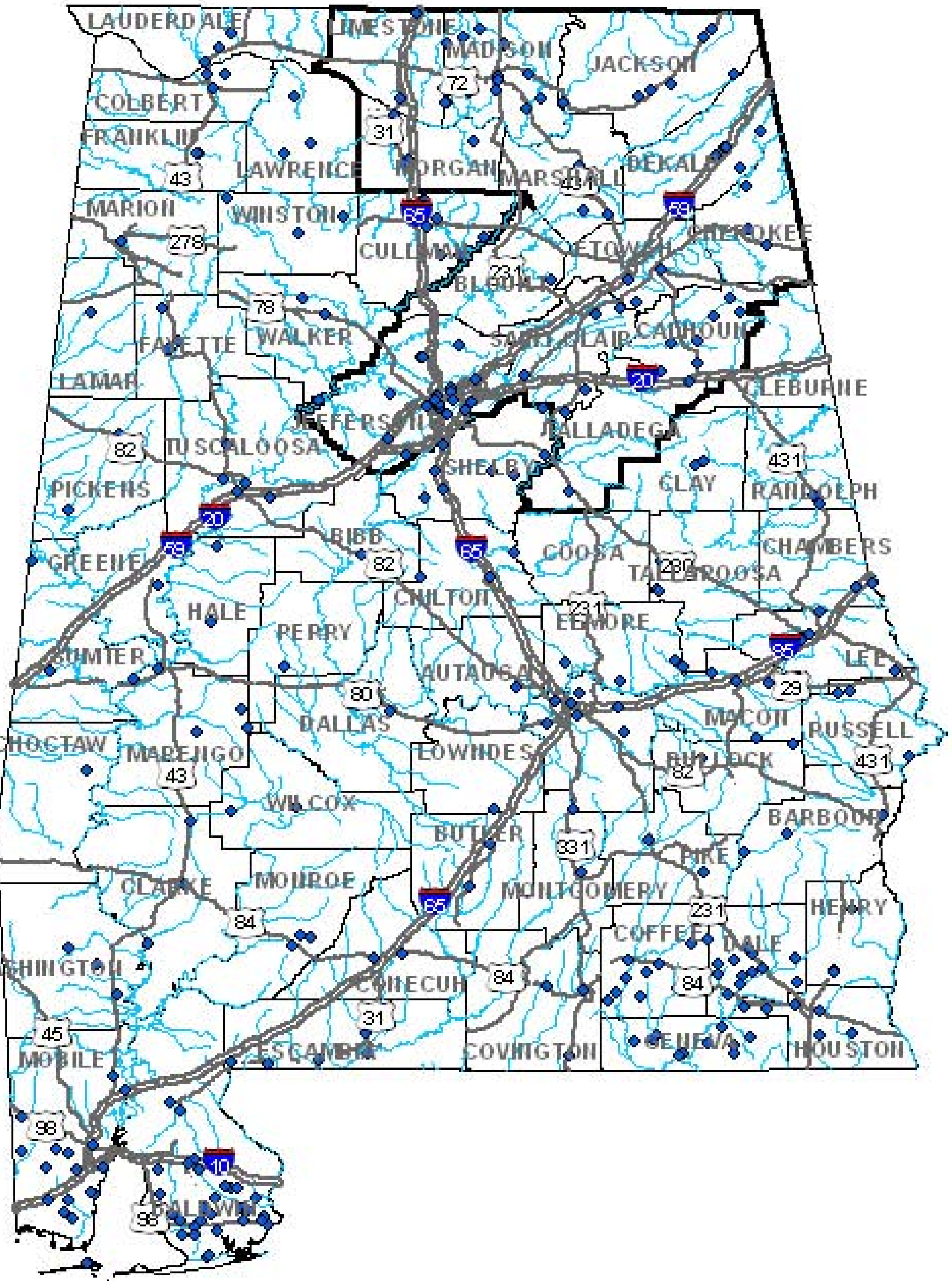
Airport Functionality - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Blount	2	2
Calhoun	12	12
Cherokee	5	5
Dekalb	7	7
Etowah	4	4
Jackson	10	10
Jefferson	24	24
Limestone	4	4
Madison	24	24
Marshall	5	5
Morgan	6	6
Saint Clair	8	8
Talladega	4	4

Legend

Airport Functionality

Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

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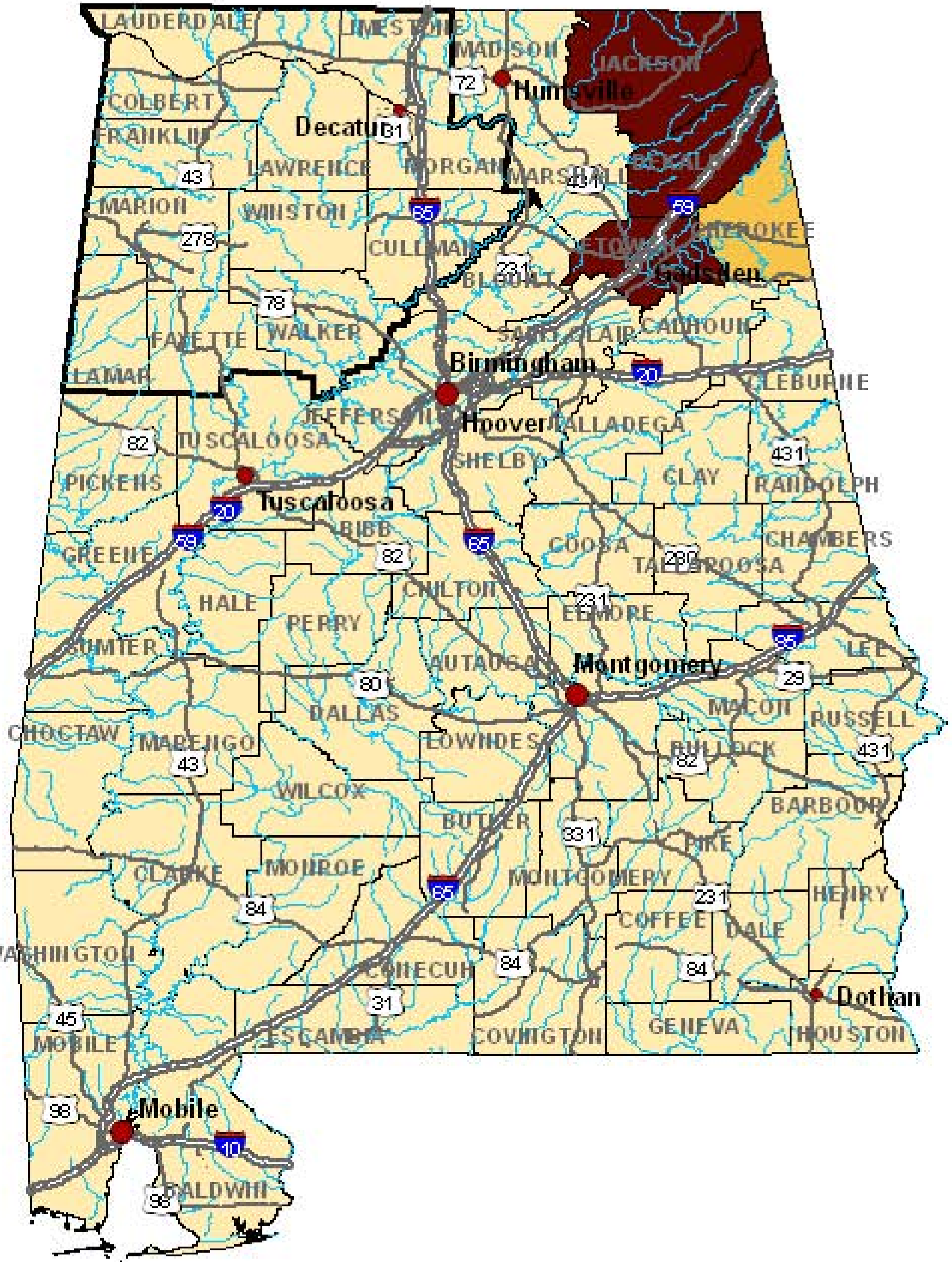
Worst Case Casualties - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Blount	0	0	0
Calhoun	1	0	1
Cherokee	10	0	10
Dekalb	63	1	64
Etowah	66	2	68
Jackson	46	1	47
Jefferson	0	0	0
Limestone	0	0	0
Madison	1	0	1
Marshall	1	0	1
Morgan	0	0	0
Saint Clair	0	0	0
Talladega	0	0	0

Legend

Worst Case Casualties

(2 AM)

- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 68

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

Critical Counties

Rivers

US Routes

Interstates

0 12.5 25 50 75

Miles

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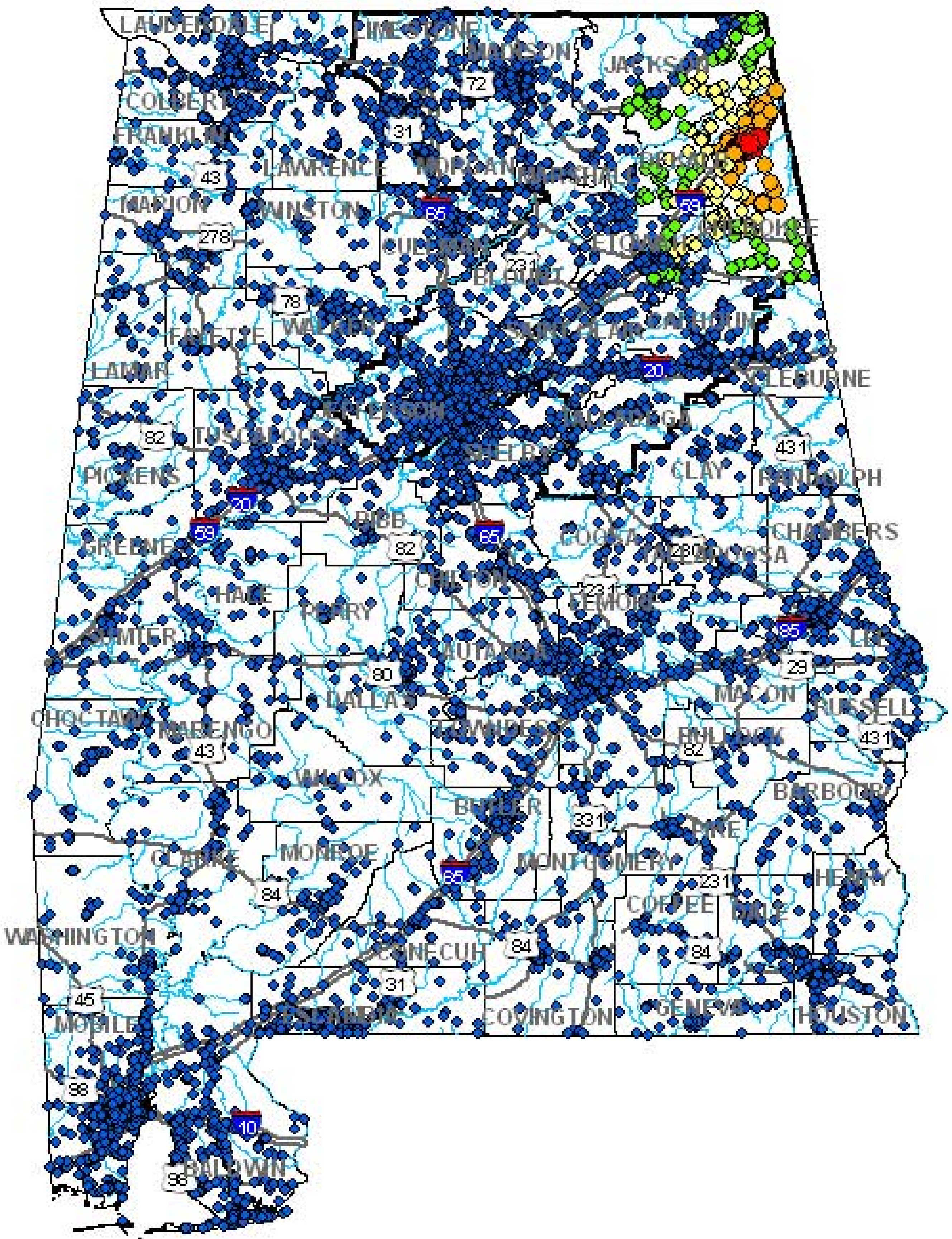
Communication Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	161	0	0
Calhoun	357	0	0
Cherokee	85	13	0
Dekalb	266	149	0
Etowah	293	0	0
Jackson	229	0	0
Jefferson	1681	0	0
Limestone	184	0	0
Madison	649	0	0
Marshall	255	0	0
Morgan	442	0	0
Saint Clair	310	0	0
Talladega	268	0	0

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Rivers

US Routes

Interstates

Critical Counties

0 12.5 25 50 75

Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

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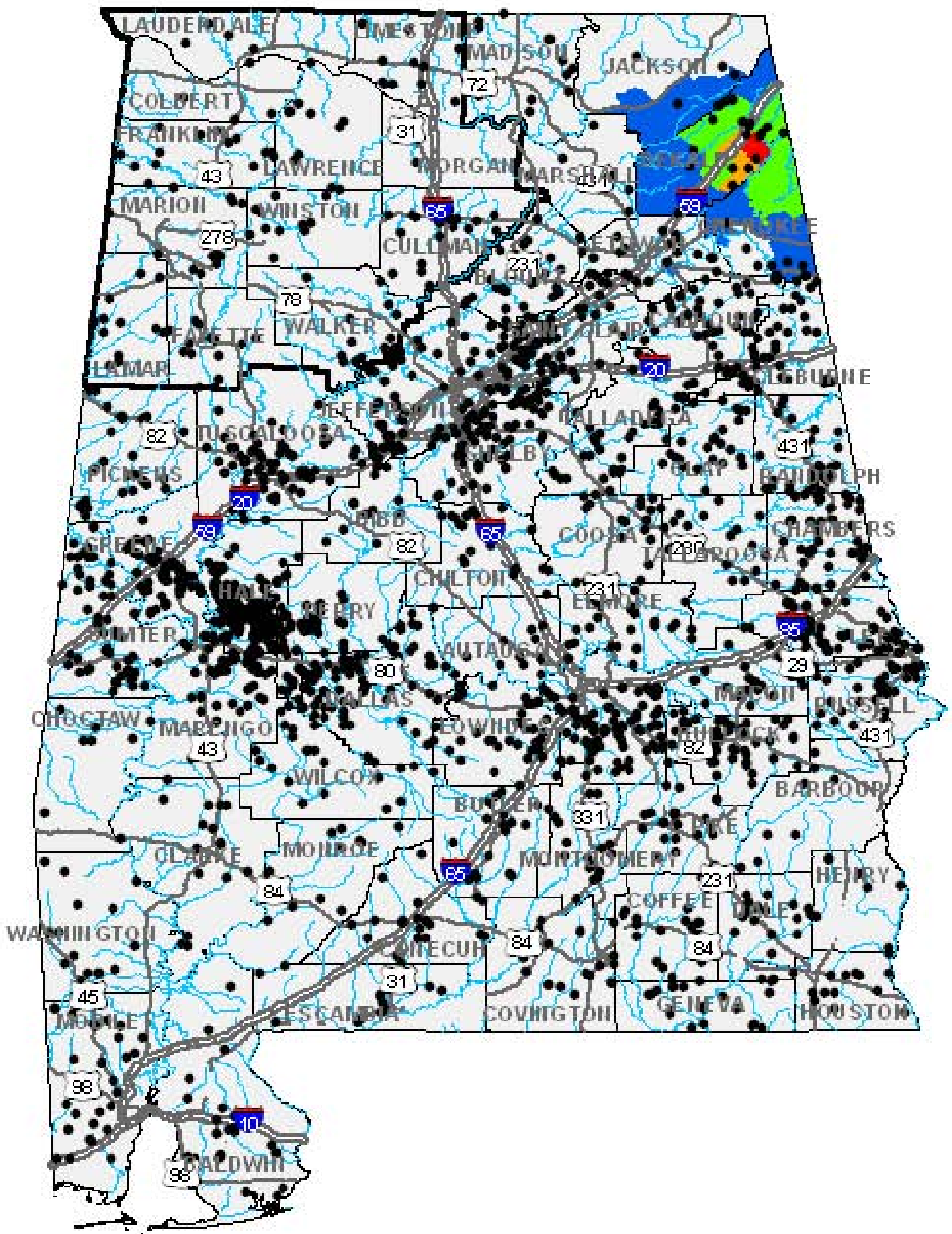
Dams - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Facilities
Blount	36
Calhoun	45
Cherokee	11
Dekalb	19
Etowah	26
Jackson	5
Jefferson	81
Limestone	12
Madison	13
Marshall	6
Morgan	2
Saint Clair	50
Talladega	41

Legend

- Dams

MMI

- < VI
- VI
- VII
- VIII
- X
- Critical Counties
- Rivers
- US Routes
- Interstates

0 12.5 25 50 75
Miles

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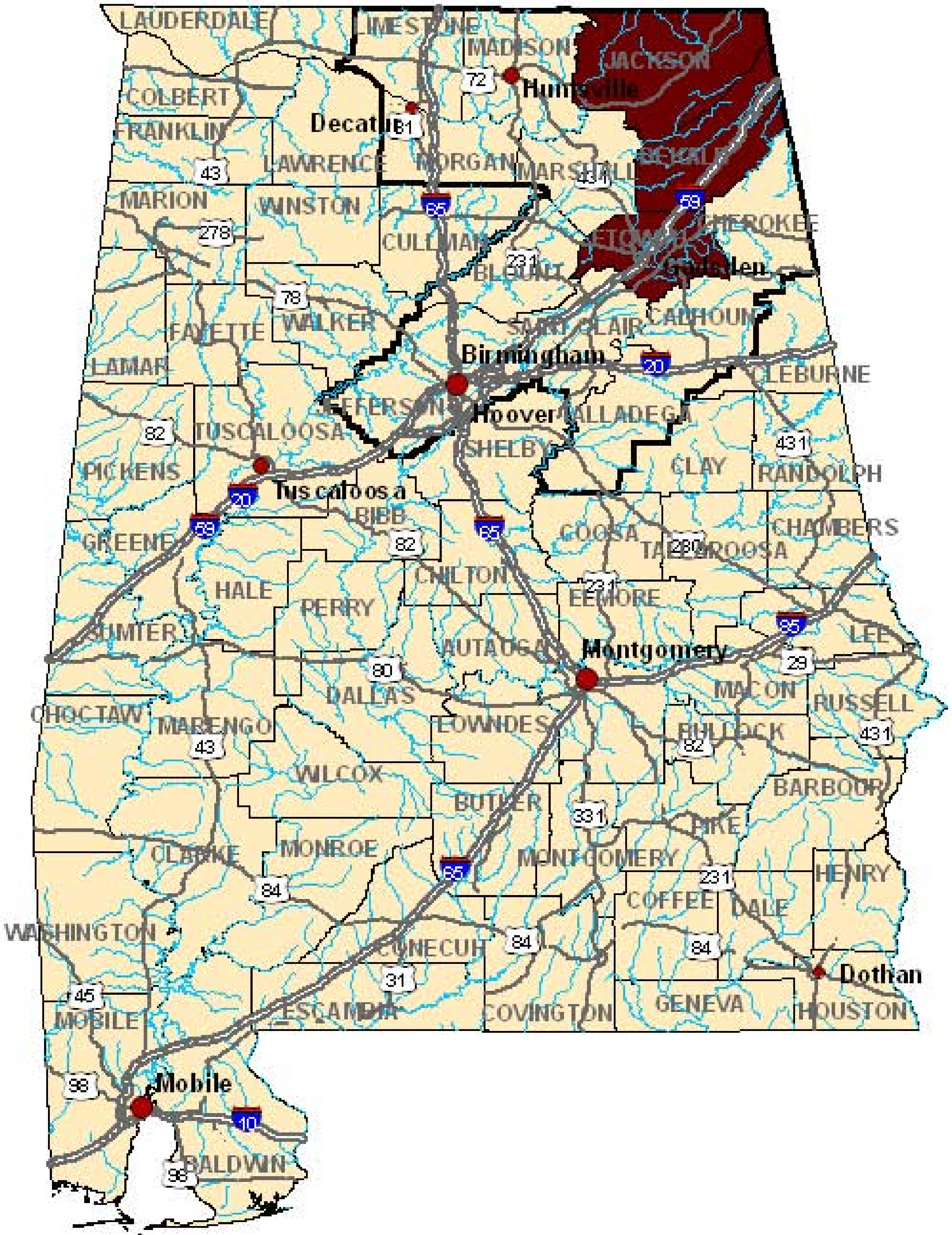
Displaced Population - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Displaced Residences	Estimate of Displaced Population
Blount	0	0
Calhoun	0	0
Cherokee	1	4
Dekalb	102	263
Etowah	323	803
Jackson	222	555
Jefferson	0	0
Limestone	0	0
Madison	0	0
Marshall	0	0
Morgan	0	0
Saint Clair	0	0
Talladega	0	0

Legend

Displaced Population
- 0 - 20
- 20 - 250
- 250 - 803

Major Cities
- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

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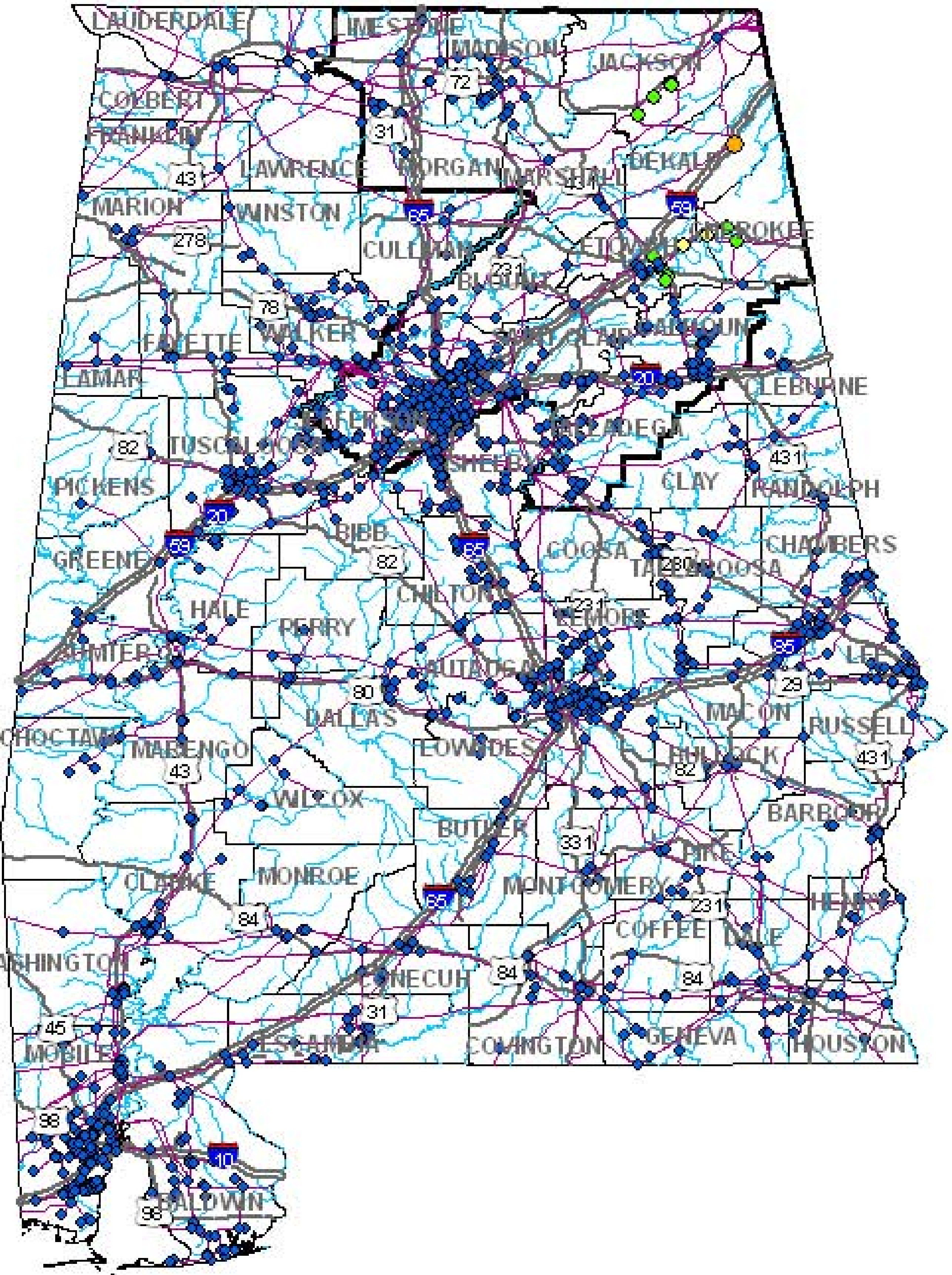
Electric Power Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	9	0	0
Calhoun	44	0	0
Cherokee	3	0	0
Dekalb	2	1	0
Etowah	20	0	0
Jackson	7	0	0
Jefferson	190	0	0
Limestone	9	0	0
Madison	32	0	0
Marshall	10	0	0
Morgan	9	0	0
Saint Clair	17	0	0
Talladega	43	0	0

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Transmission Lines
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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Emergency Operation Center Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Cherokee	1	0	0
Etowah	1	0	0
Jefferson	2	0	0
Madison	1	0	0
Marshall	2	0	0
Talladega	1	0	0
Blount	0	0	0
Calhoun	0	0	0
Dekalb	0	0	0
Jackson	0	0	0
Limestone	0	0	0
Morgan	0	0	0
Saint Clair	0	0	0

Legend

Emergency Operation Centers

At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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EOC Functionality - East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Cherokee	1	1
Etowah	1	1
Jefferson	2	2
Madison	1	1
Marshall	2	2
Talladega	1	1
Blount	0	0
Calhoun	0	0
Dekalb	0	0
Jackson	0	0
Limestone	0	0
Morgan	0	0
Saint Clair	0	0

Legend

Emergency Operation Centers

Functionality at Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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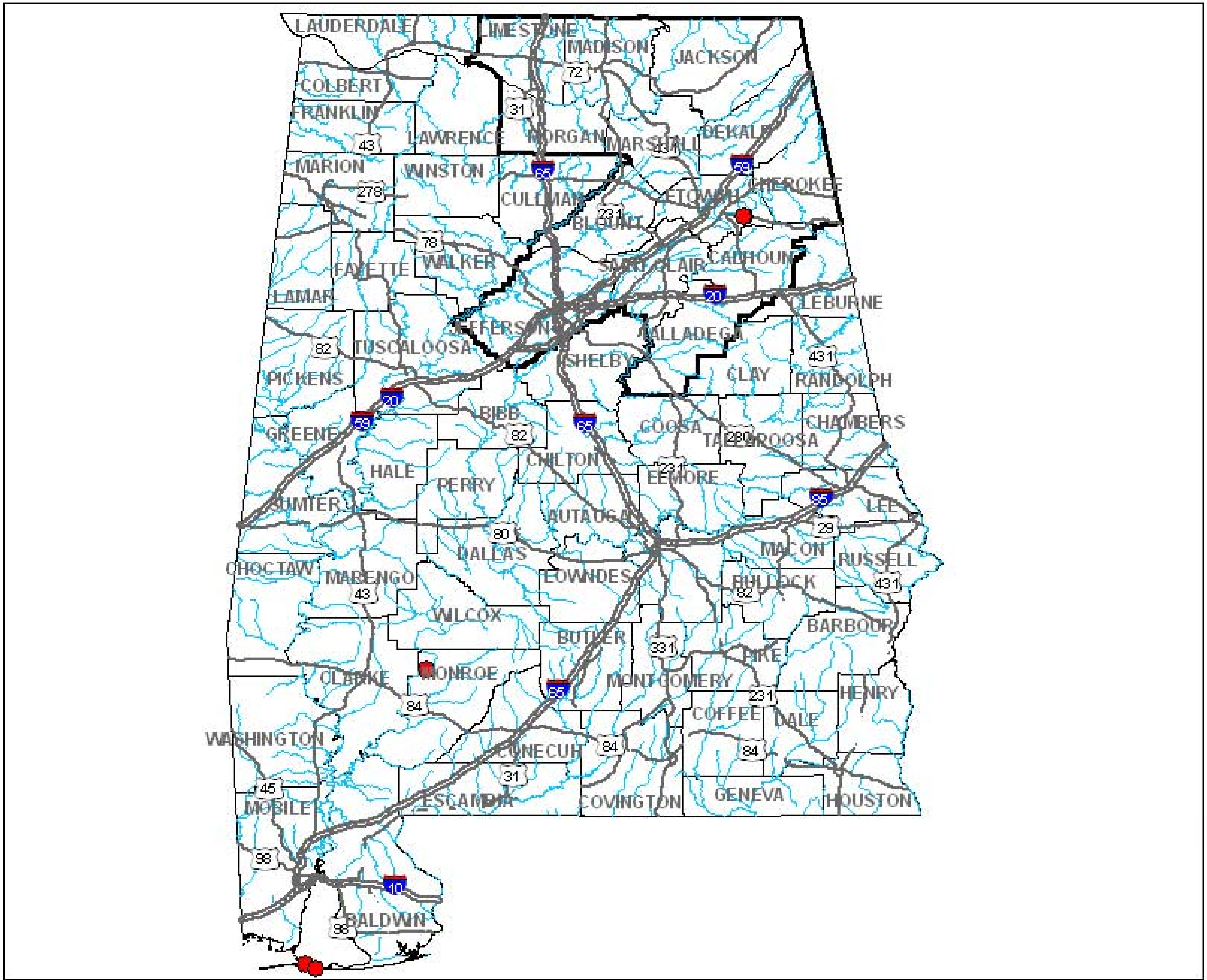
Ferry Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Etowah	2	2	2
Blount	0	0	0
Calhoun	0	0	0
Cherokee	0	0	0
Dekalb	0	0	0
Jackson	0	0	0
Jefferson	0	0	0
Limestone	0	0	0
Madison	0	0	0
Marshall	0	0	0
Morgan	0	0	0
Saint Clair	0	0	0
Talladega	0	0	0

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

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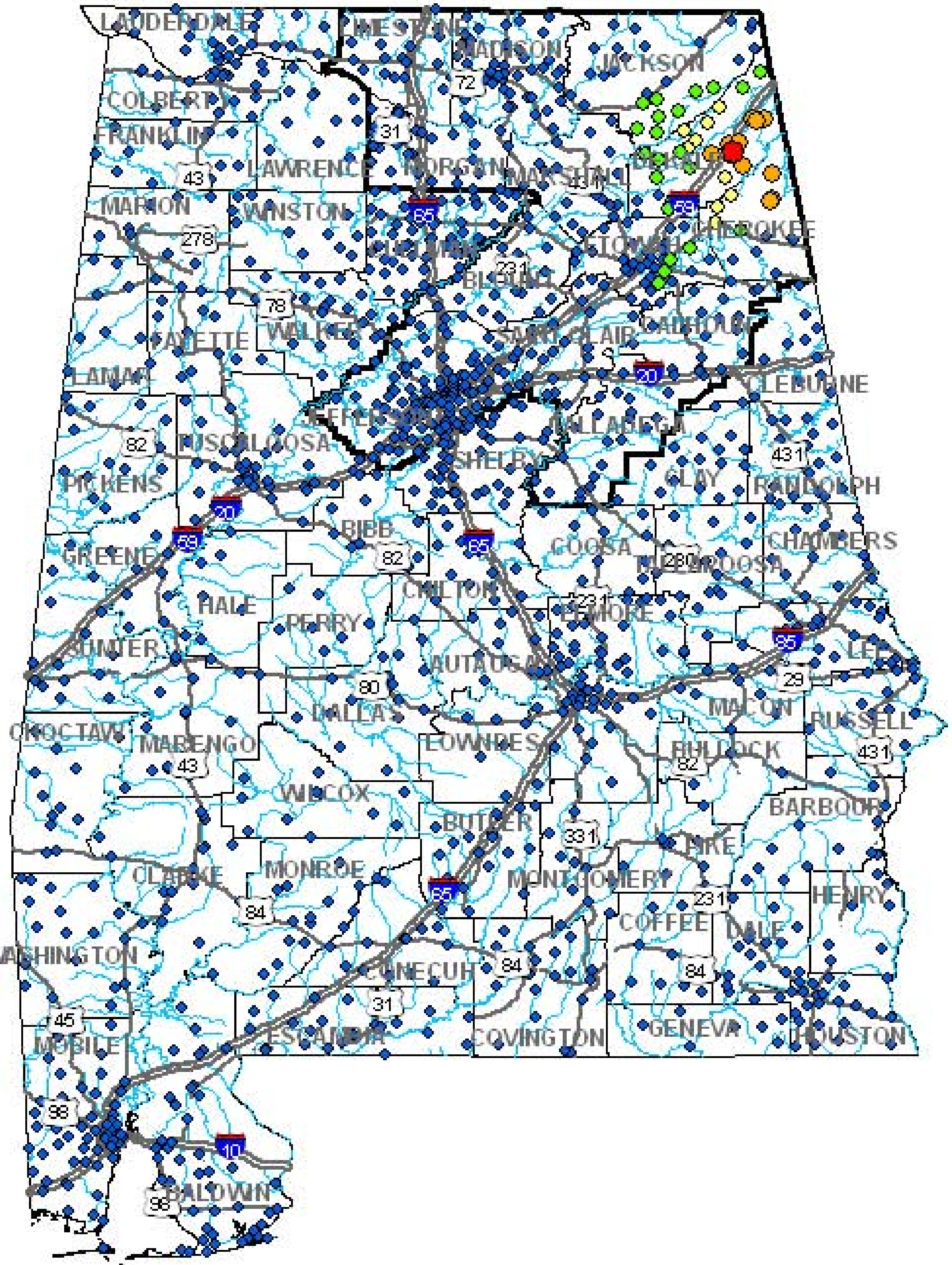
Fire Station Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	22	0	0
Calhoun	23	0	0
Cherokee	13	3	0
Dekalb	29	9	0
Etowah	32	0	0
Jackson	27	0	0
Jefferson	106	0	0
Limestone	20	0	0
Madison	46	0	0
Marshall	23	0	0
Morgan	34	0	0
Saint Clair	23	0	0
Talladega	21	0	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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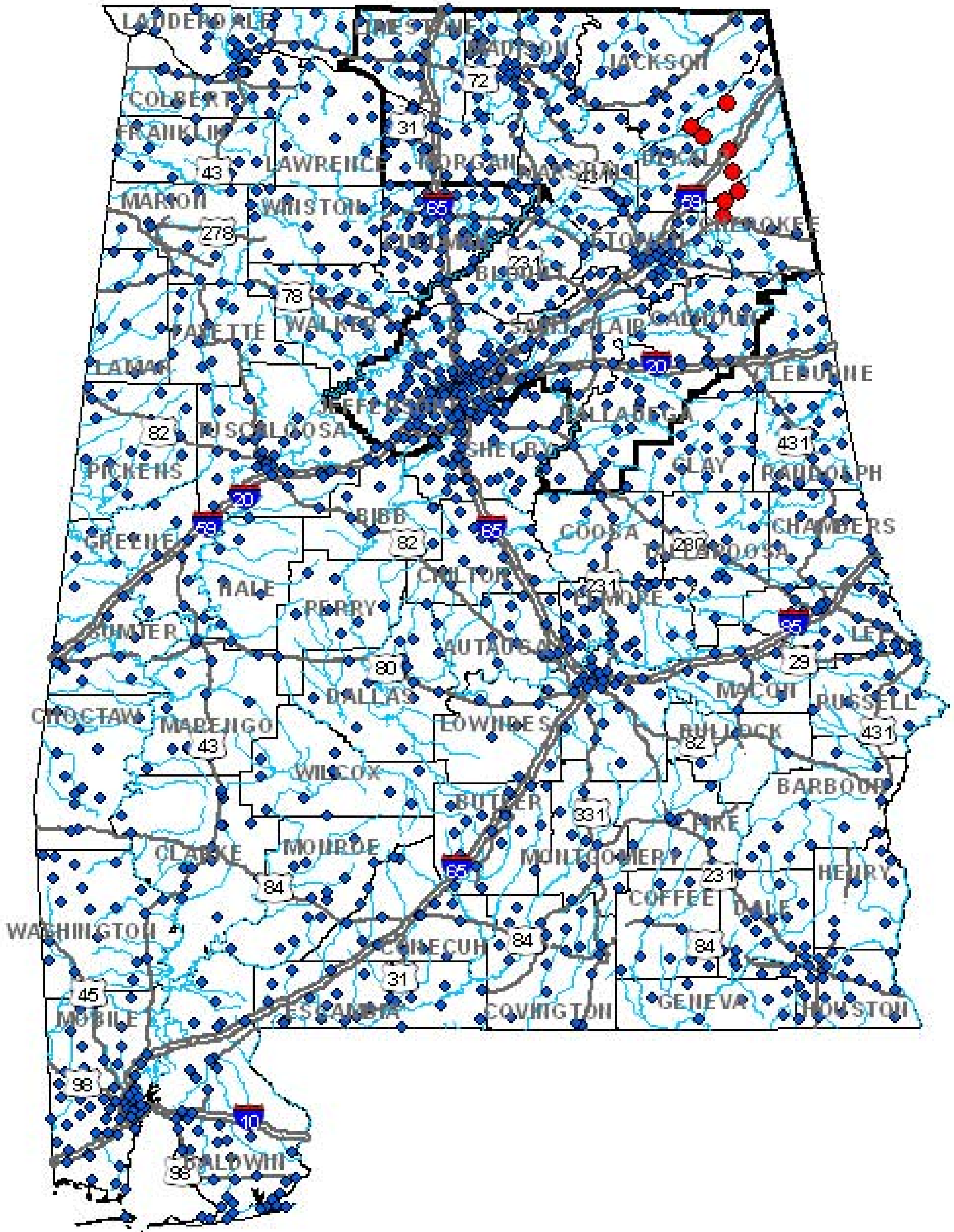
Fire Station Functionality - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Blount	22	22
Calhoun	23	23
Cherokee	7	13
Dekalb	13	29
Etowah	32	32
Jackson	27	27
Jefferson	106	106
Limestone	20	20
Madison	46	46
Marshall	23	23
Morgan	34	34
Saint Clair	23	23
Talladega	21	21

Legend

Fire Station Functionality

Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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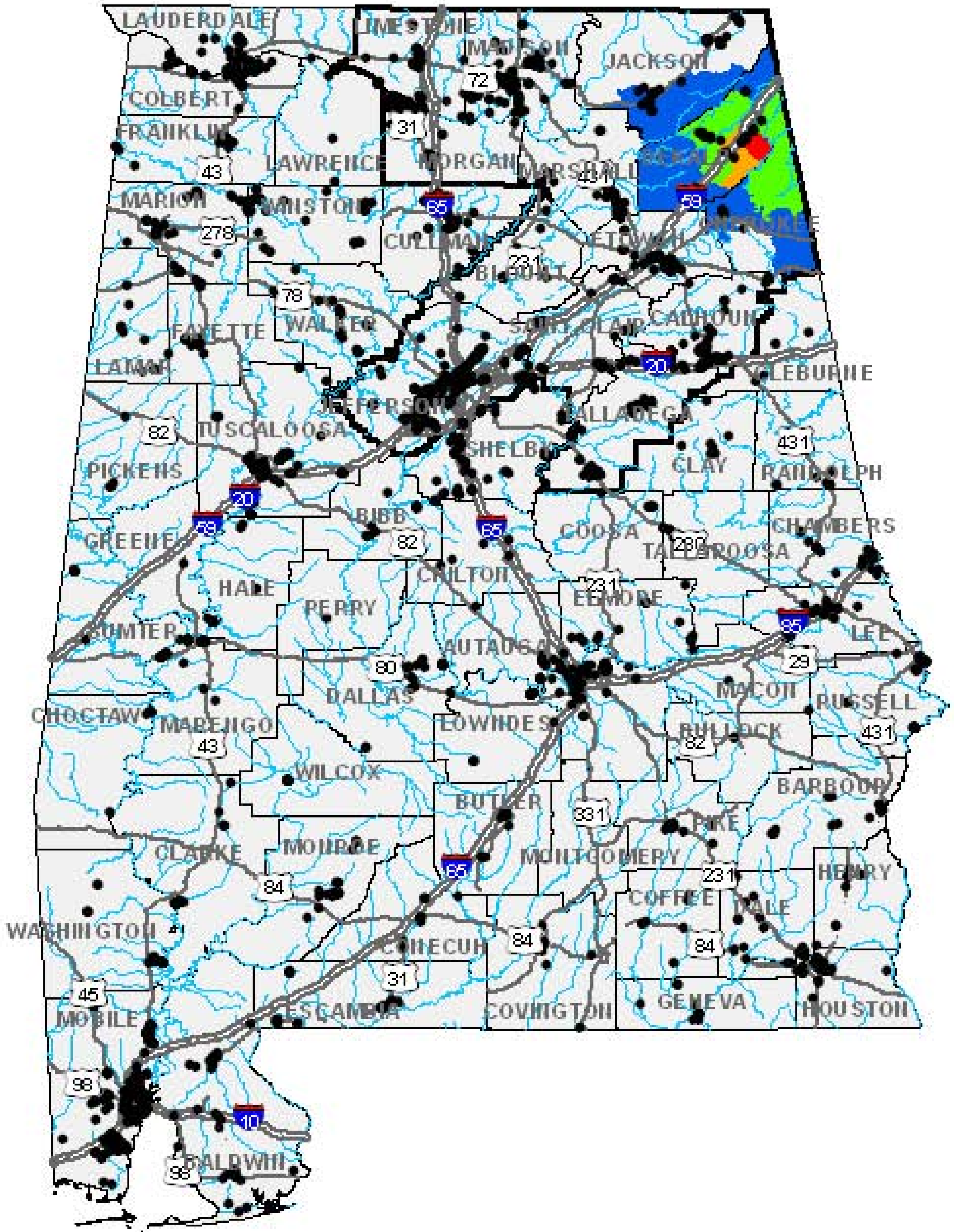
Hazardous Materials Facilities - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Facilities
Blount	17
Calhoun	109
Cherokee	10
Dekalb	36
Etowah	78
Jackson	88
Jefferson	469
Limestone	47
Madison	137
Marshall	71
Morgan	193
Saint Clair	54
Talladega	78

Legend

- Hazardous Materials Facilities

MMI

- < VI
- VI
- VII
- VIII
- X
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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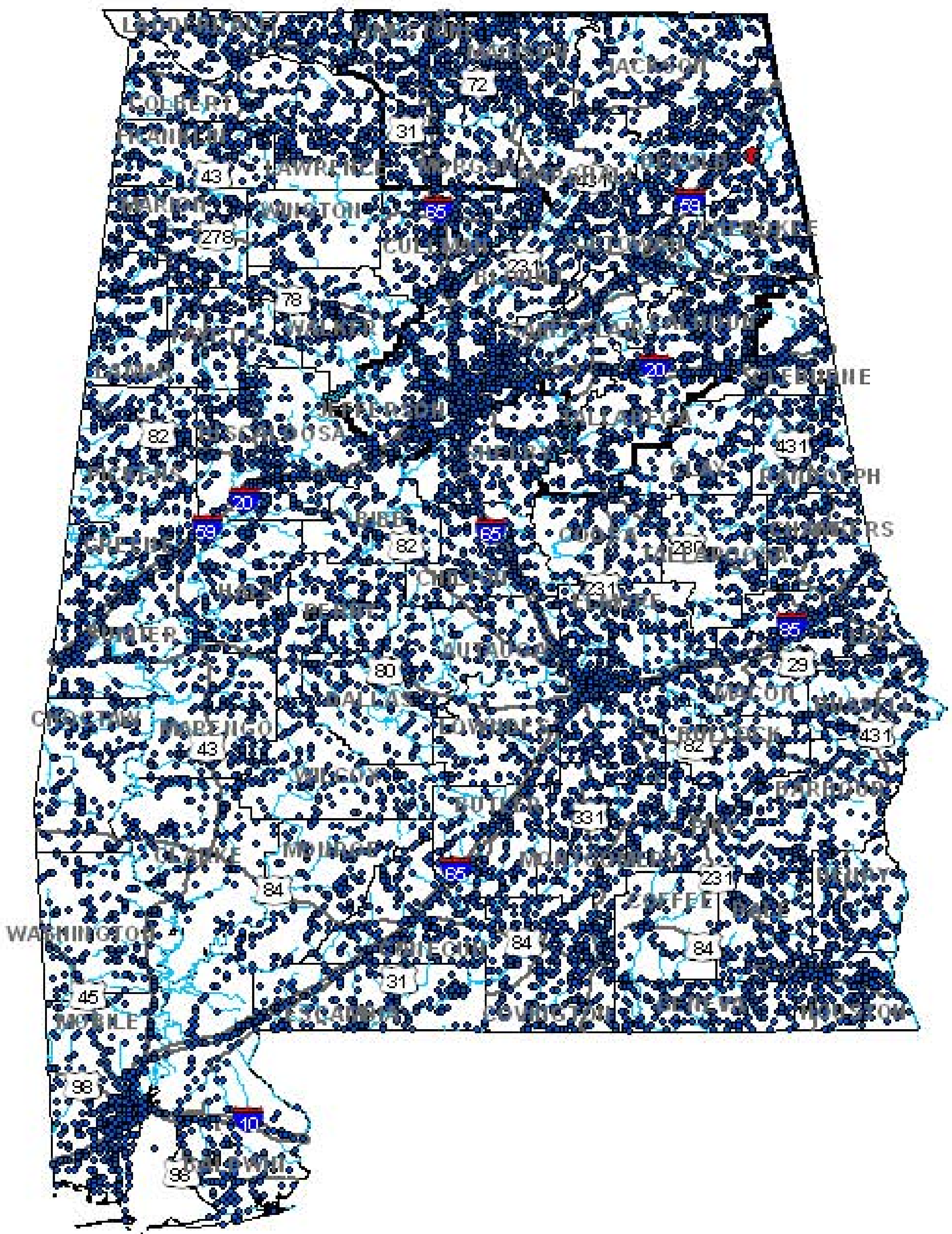
Highway Bridge Functionality -East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Blount	178	178
Calhoun	288	288
Cherokee	159	159
Dekalb	286	287
Etowah	209	209
Jackson	270	270
Jefferson	958	958
Limestone	299	299
Madison	567	567
Marshall	165	165
Morgan	239	239
Saint Clair	163	163
Talladega	232	232

Legend

Highway Bridge Functionality

Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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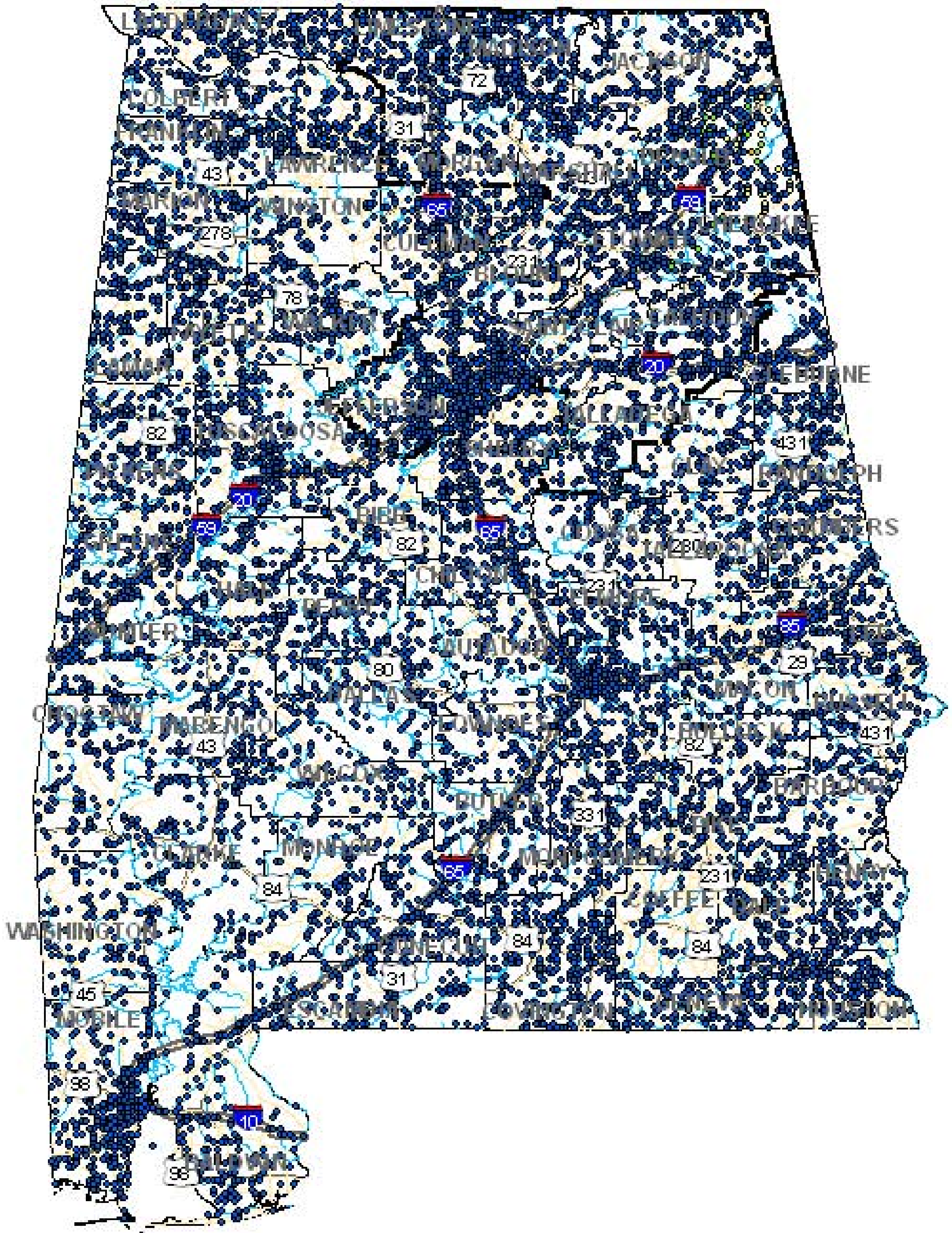
Highway Bridge & Segment Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	178	0	0
Calhoun	288	0	0
Cherokee	159	0	0
Dekalb	287	1	0
Etowah	209	0	0
Jackson	270	0	0
Jefferson	958	0	0
Limestone	299	0	0
Madison	567	0	0
Marshall	165	0	0
Morgan	239	0	0
Saint Clair	163	0	0
Talladega	232	0	0

Legend

Highway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Highway Segment Damage

At Least Moderate

- Highly Unlikely
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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Hospital Damage -East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	1	0	0
Calhoun	4	0	0
Cherokee	1	0	0
Dekalb	1	1	0
Etowah	4	0	0
Jackson	1	0	0
Jefferson	20	0	0
Limestone	1	0	0
Madison	5	0	0
Marshall	2	0	0
Morgan	5	0	0
Saint Clair	1	0	0
Talladega	2	0	0

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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Hospital Functionality - East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Blount	1	1
Calhoun	4	4
Cherokee	1	1
Dekalb	0	1
Etowah	4	4
Jackson	1	1
Jefferson	20	20
Limestone	1	1
Madison	5	5
Marshall	2	2
Morgan	5	5
Saint Clair	1	1
Talladega	2	2

Legend

Hospital Functionality

Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

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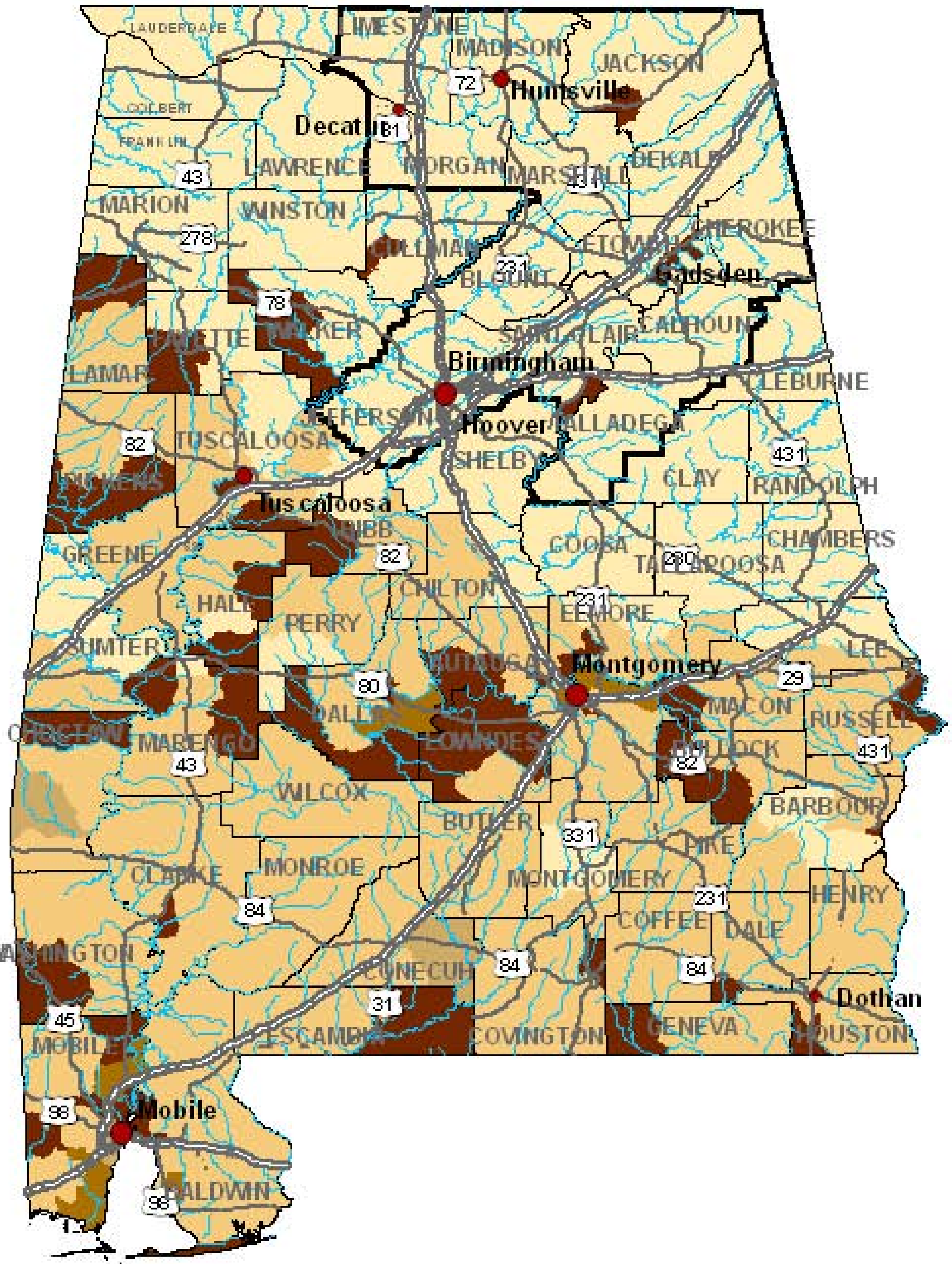
Liquefaction Susceptibility - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Minimum Susceptibility	Maximum Susceptibility
Blount	Very Low	Very Low
Calhoun	Very Low	Very Low
Cherokee	Very Low	Very Low
Dekalb	Very Low	Very Low
Etowah	Very Low	Very High
Jackson	Very Low	Very High
Jefferson	Very Low	Very Low
Limestone	Very Low	Very Low
Madison	Very Low	Very Low
Marshall	Very Low	Very Low
Morgan	Very Low	Very Low
Saint Clair	Very Low	Very High
Talladega	Very Low	Very Low

Legend

Liquefaction Susceptibility

- Very Low
- Low
- Moderate
- High
- Very High

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

Mid-America Earthquake Center

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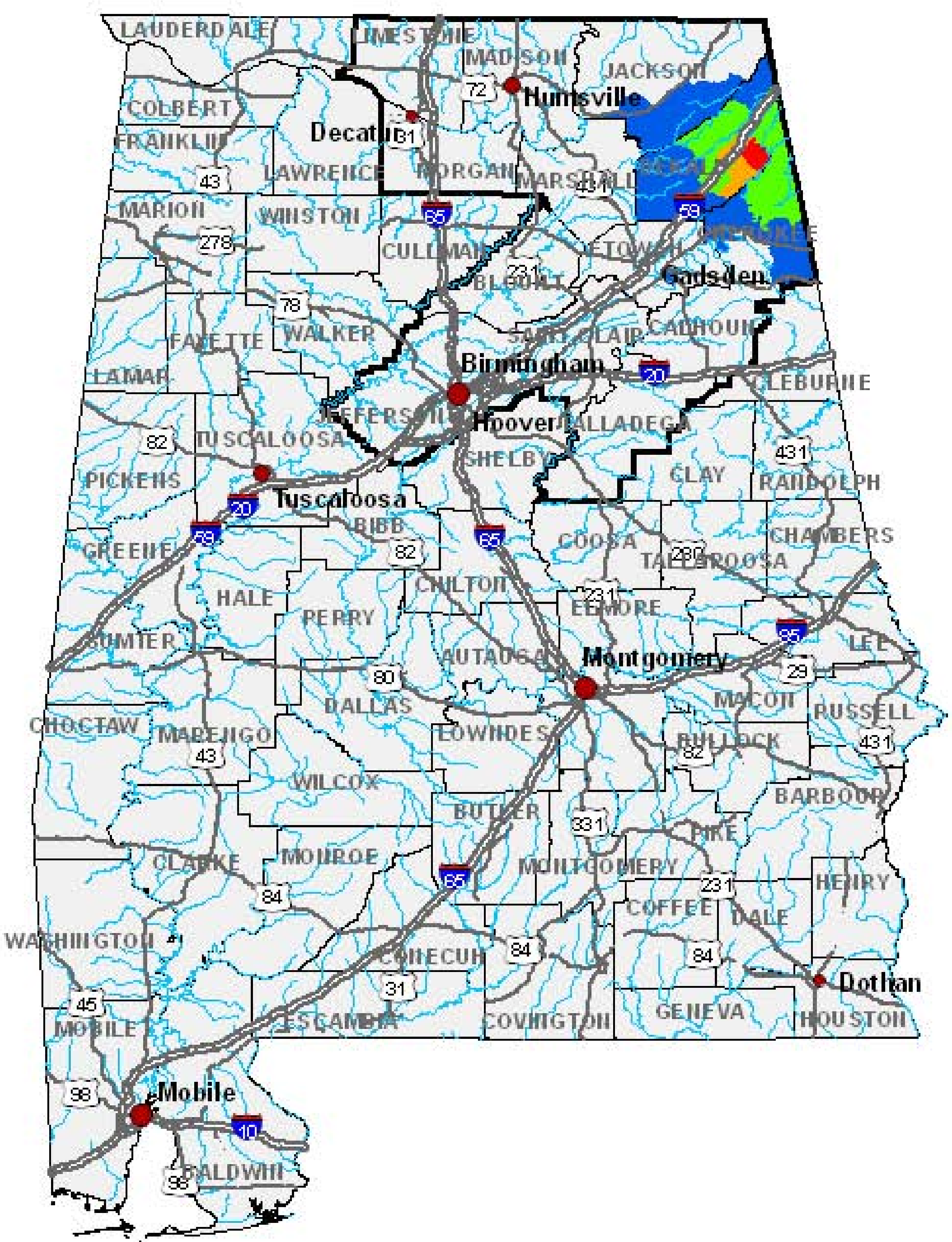
Modified Mercalli Intensity - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Max. MMI
Blount	< VI
Calhoun	VI
Cherokee	X
Dekalb	X
Etowah	VI
Jackson	VII
Jefferson	< VI
Limestone	< VI
Madison	< VI
Marshall	VI
Morgan	< VI
Saint Clair	< VI
Talladega	< VI

Legend

Modified Mercalli Intensity

MMI

- < VI
- VI
- VII
- VIII
- X

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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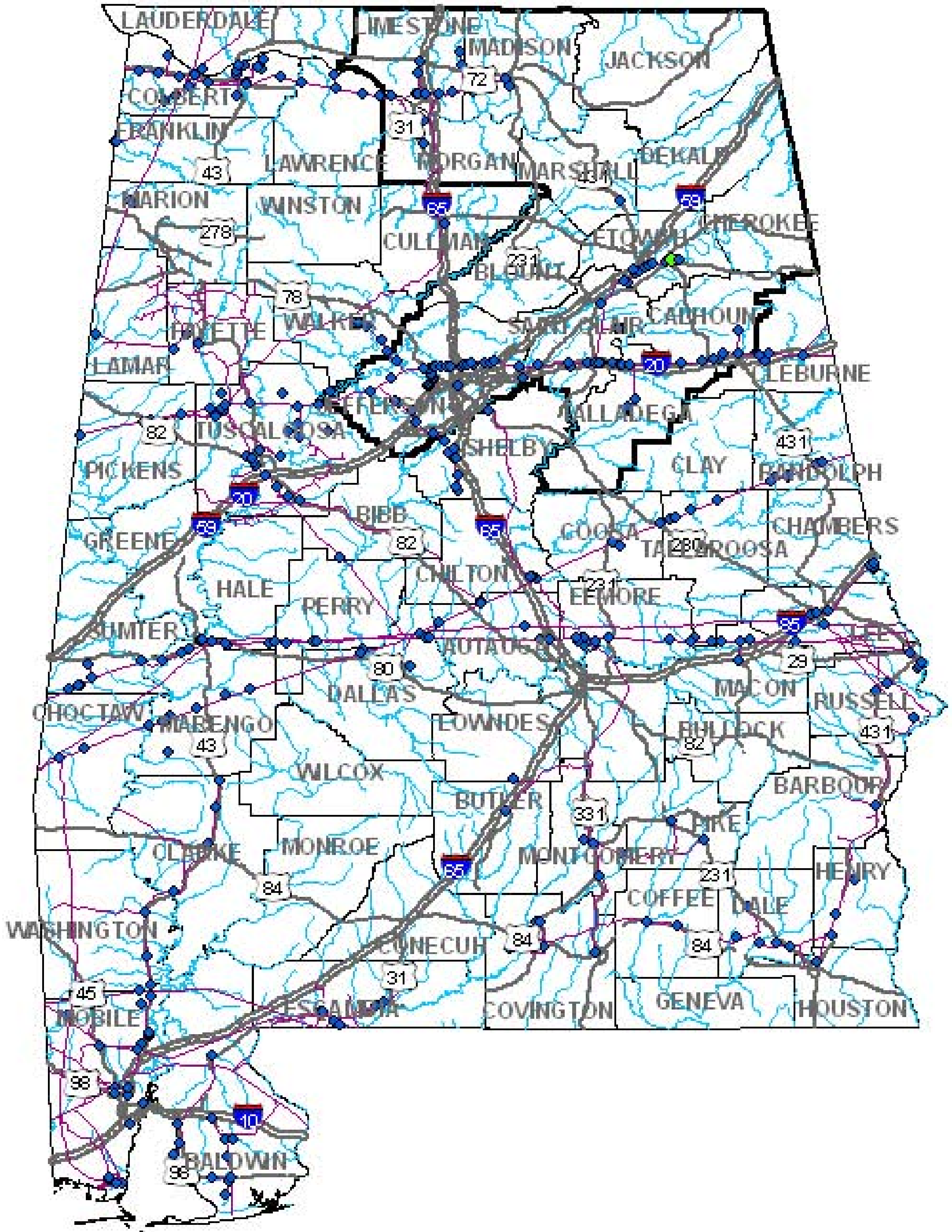
Natural Gas Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Calhoun	8	0	0
Etowah	12	0	0
Jefferson	38	0	0
Limestone	10	0	0
Madison	4	0	0
Marshall	1	0	0
Morgan	4	0	0
Saint Clair	14	0	0
Talladega	9	0	0
Blount	0	0	0
Cherokee	0	0	0
Dekalb	0	0	0
Jackson	0	0	0

Legend

Natural Gas Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Transmission Lines
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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Oil Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Calhoun	5	0	0
Jefferson	30	0	0
Morgan	1	0	0
Talladega	2	0	0
Blount	0	0	0
Cherokee	0	0	0
Dekalb	0	0	0
Etowah	0	0	0
Jackson	0	0	0
Limestone	0	0	0
Madison	0	0	0
Marshall	0	0	0
Saint Clair	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Transmission Lines
Rivers
US Routes
Interstates
Critical Counties

0 12.5 25 50 75
Miles

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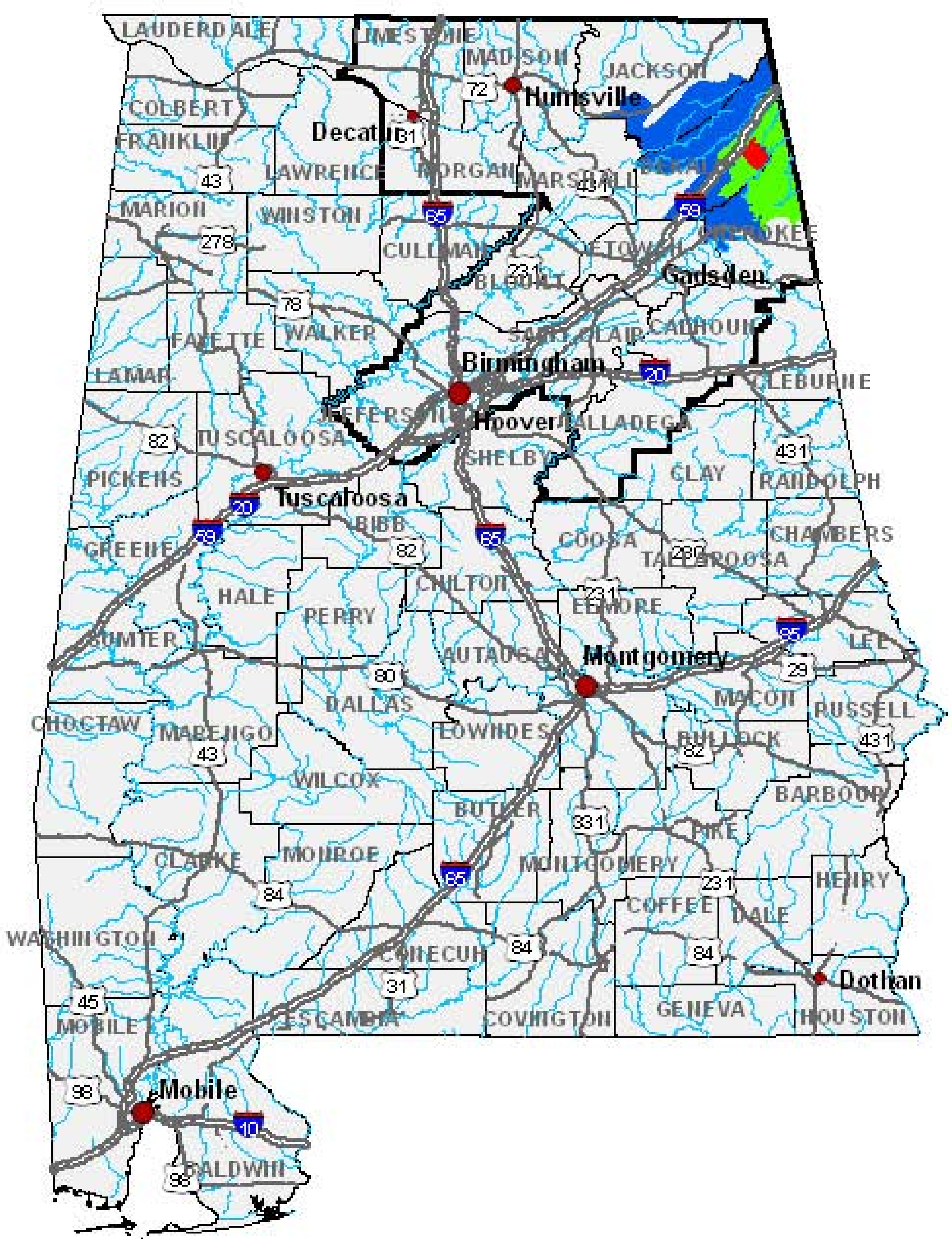
Peak Ground Acceleration - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Min. PGA	Max. PGA
Blount	0.03	0.07
Calhoun	0.05	0.13
Cherokee	0.07	0.79
Dekalb	0.09	0.79
Etowah	0.05	0.19
Jackson	0.05	0.25
Jefferson	0.02	0.05
Limestone	0.03	0.05
Madison	0.04	0.08
Marshall	0.05	0.17
Morgan	0.03	0.06
Saint Clair	0.03	0.07
Talladega	0.02	0.06

Legend

PGA (g)

- 0.05 - 0.15
- 0.15 - 0.3
- 0.3 - 0.45
- 0.45 - 0.6
- 0.6 - 0.8

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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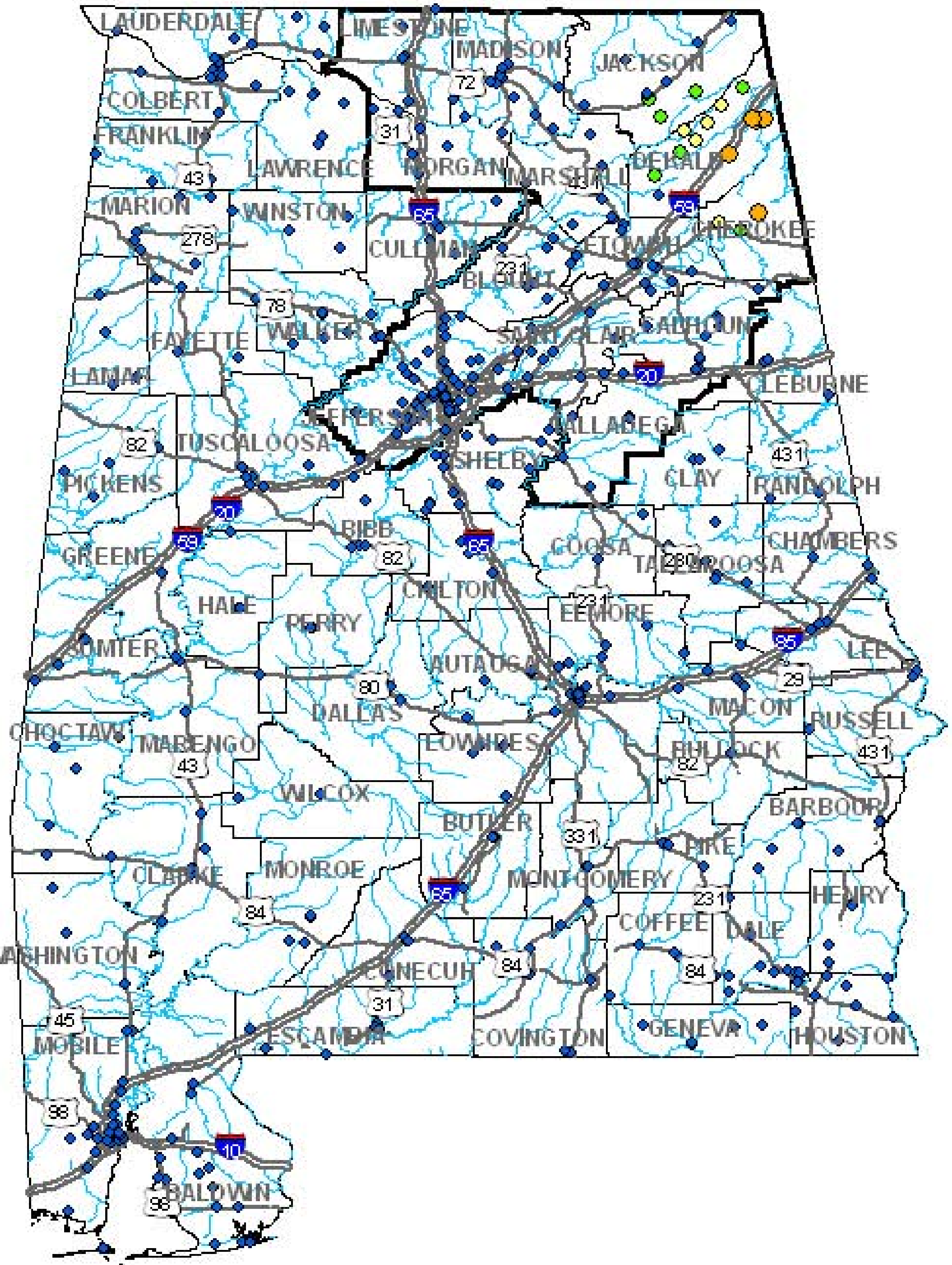
Police Station Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	7	0	0
Calhoun	10	0	0
Cherokee	4	1	0
Dekalb	14	5	0
Etowah	12	0	0
Jackson	10	0	0
Jefferson	46	0	0
Limestone	5	0	0
Madison	16	0	0
Marshall	9	0	0
Morgan	9	0	0
Saint Clair	12	0	0
Talladega	7	0	0

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

Mid-America Earthquake Center

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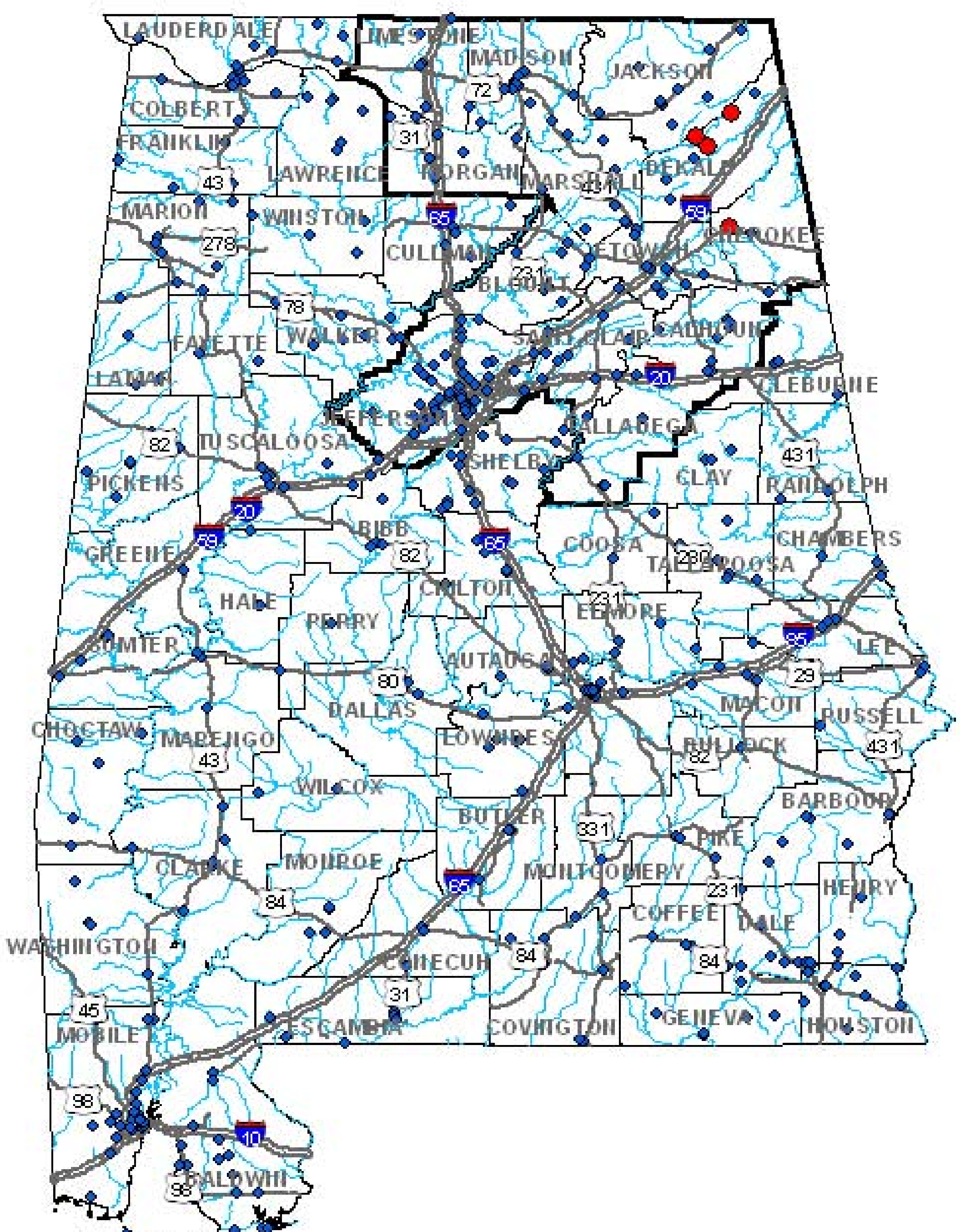
Police Station Functionality - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Blount	7	7
Calhoun	10	10
Cherokee	2	4
Dekalb	5	14
Etowah	12	12
Jackson	10	10
Jefferson	46	46
Limestone	5	5
Madison	16	16
Marshall	9	9
Morgan	9	9
Saint Clair	12	12
Talladega	7	7

Legend

Police Station Functionality

Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center

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Port Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Jackson	4	0	0
Jefferson	14	0	0
Limestone	3	0	0
Madison	2	0	0
Marshall	16	0	0
Morgan	15	0	0
Blount	0	0	0
Calhoun	0	0	0
Cherokee	0	0	0
Dekalb	0	0	0
Etowah	0	0	0
Saint Clair	0	0	0
Talladega	0	0	0

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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Potable Water Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	3	0	0
Dekalb	1	1	0
Etowah	2	0	0
Jackson	2	0	0
Jefferson	3	0	0
Limestone	1	0	0
Marshall	2	0	0
Calhoun	0	0	0
Cherokee	0	0	0
Madison	0	0	0
Morgan	0	0	0
Saint Clair	0	0	0
Talladega	0	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Potable Water Distribution Lines

No. Leaks

- 0 - 5
- 5 - 10
- 10 - 32
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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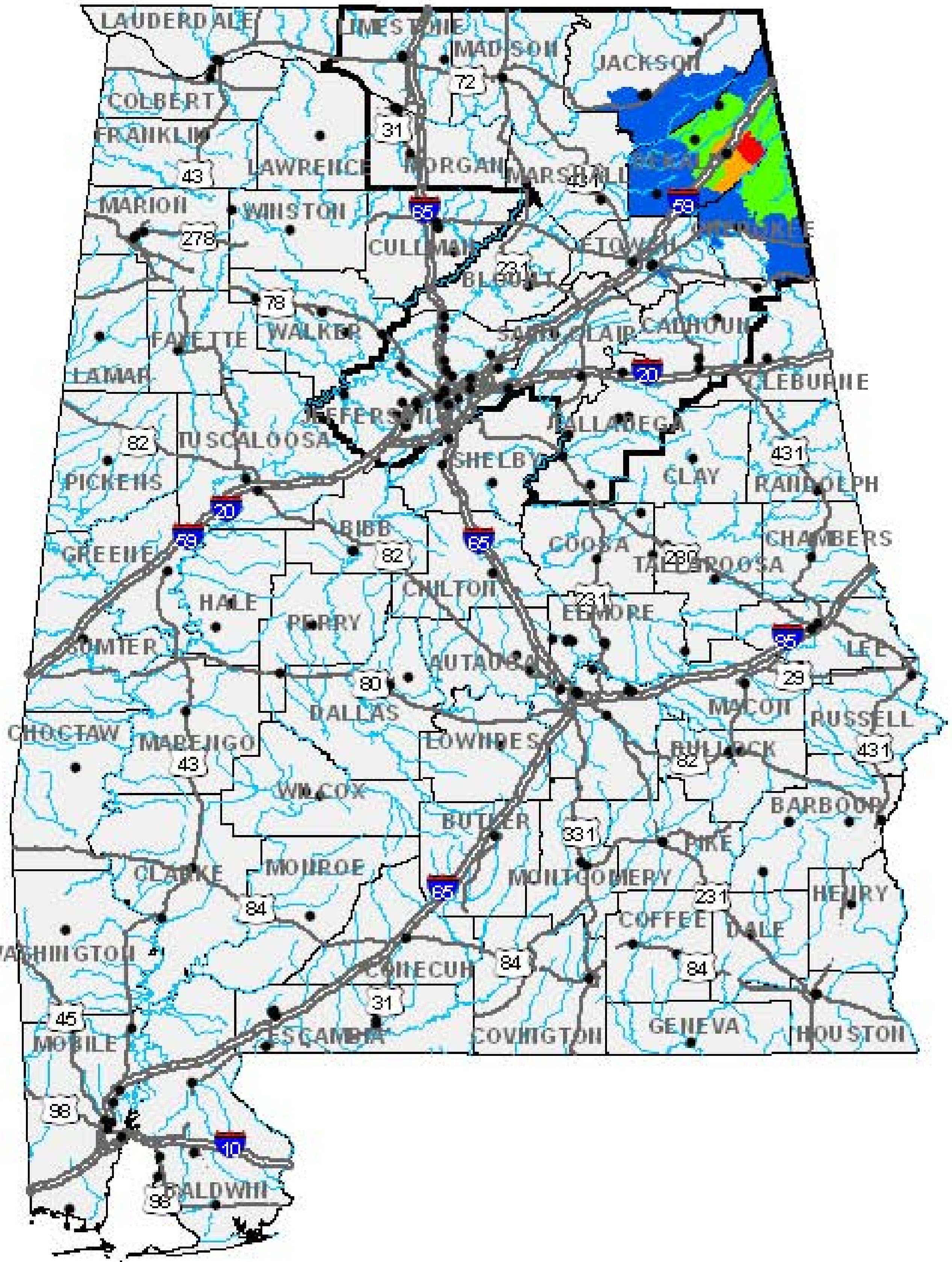
Prisons - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Facilities
Blount	1
Calhoun	5
Cherokee	1
Dekalb	6
Etowah	3
Jackson	4
Jefferson	24
Limestone	3
Madison	1
Marshall	3
Morgan	4
Saint Clair	2
Talladega	7

Legend

- Prisons

MMI

- < VI
- VI
- VII
- VIII
- X
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

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Theresa Jefferson, Principal Investigator

Railway Bridge Functionality - East Tennessee Seismic Zone: M5.9 Event

March 2008

State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Blount	2	2
Calhoun	9	9
Etowah	2	2
Jackson	3	3
Jefferson	28	28
Limestone	3	3
Saint Clair	3	3
Talladega	7	7
Cherokee	0	0
Dekalb	0	0
Madison	0	0
Marshall	0	0
Morgan	0	0

Legend

Railway Bridge Functionality

Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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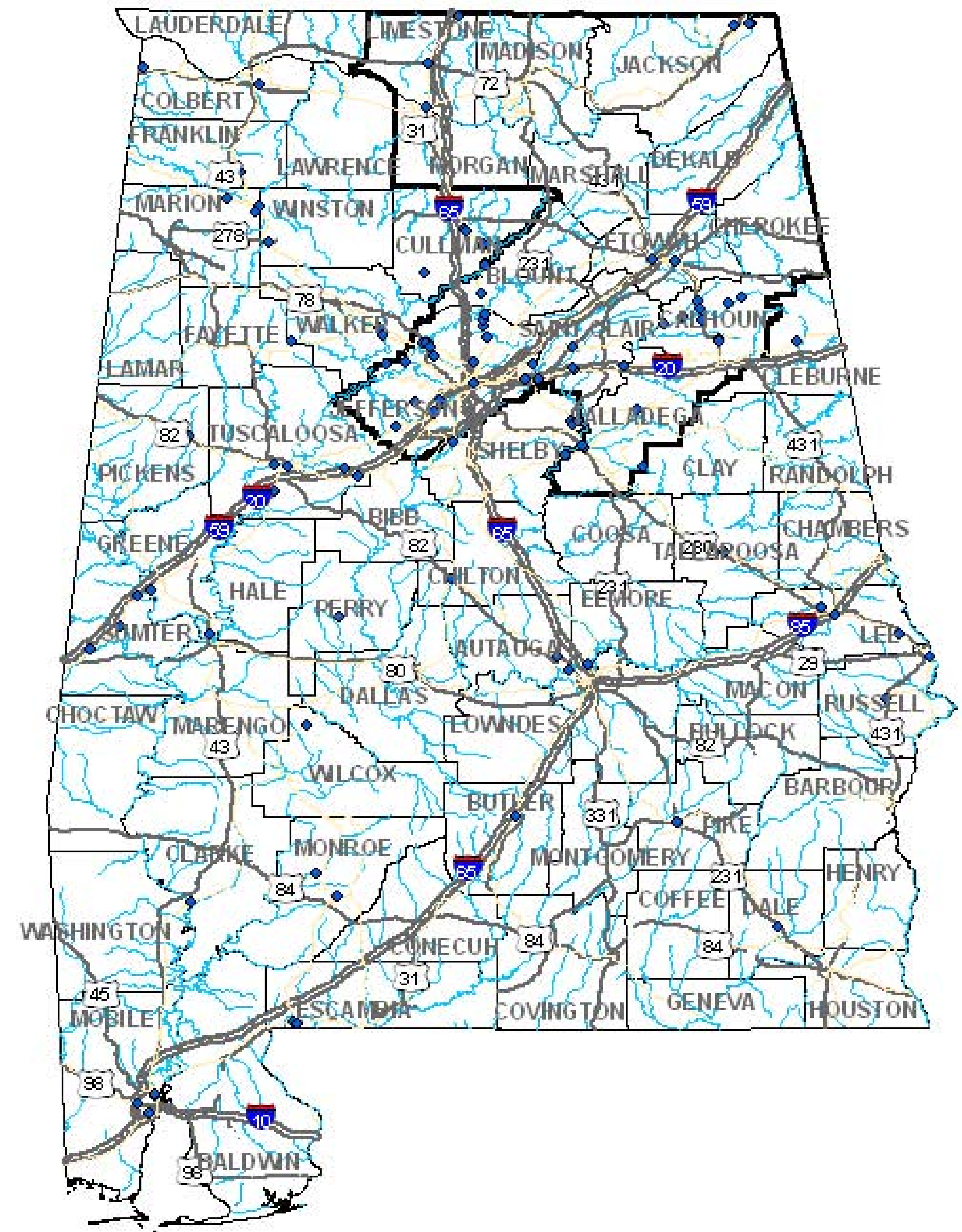
Railway Bridge & Segment Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	2	0	0
Calhoun	9	0	0
Etowah	2	0	0
Jackson	3	0	0
Jefferson	28	0	0
Limestone	3	0	0
Saint Clair	3	0	0
Talladega	7	0	0
Cherokee	0	0	0
Dekalb	0	0	0
Madison	0	0	0
Marshall	0	0	0
Morgan	0	0	0

Legend

Railway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Railway Segment Damage

At Least Moderate

- Highly Unlikely
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

Mid-America Earthquake Center

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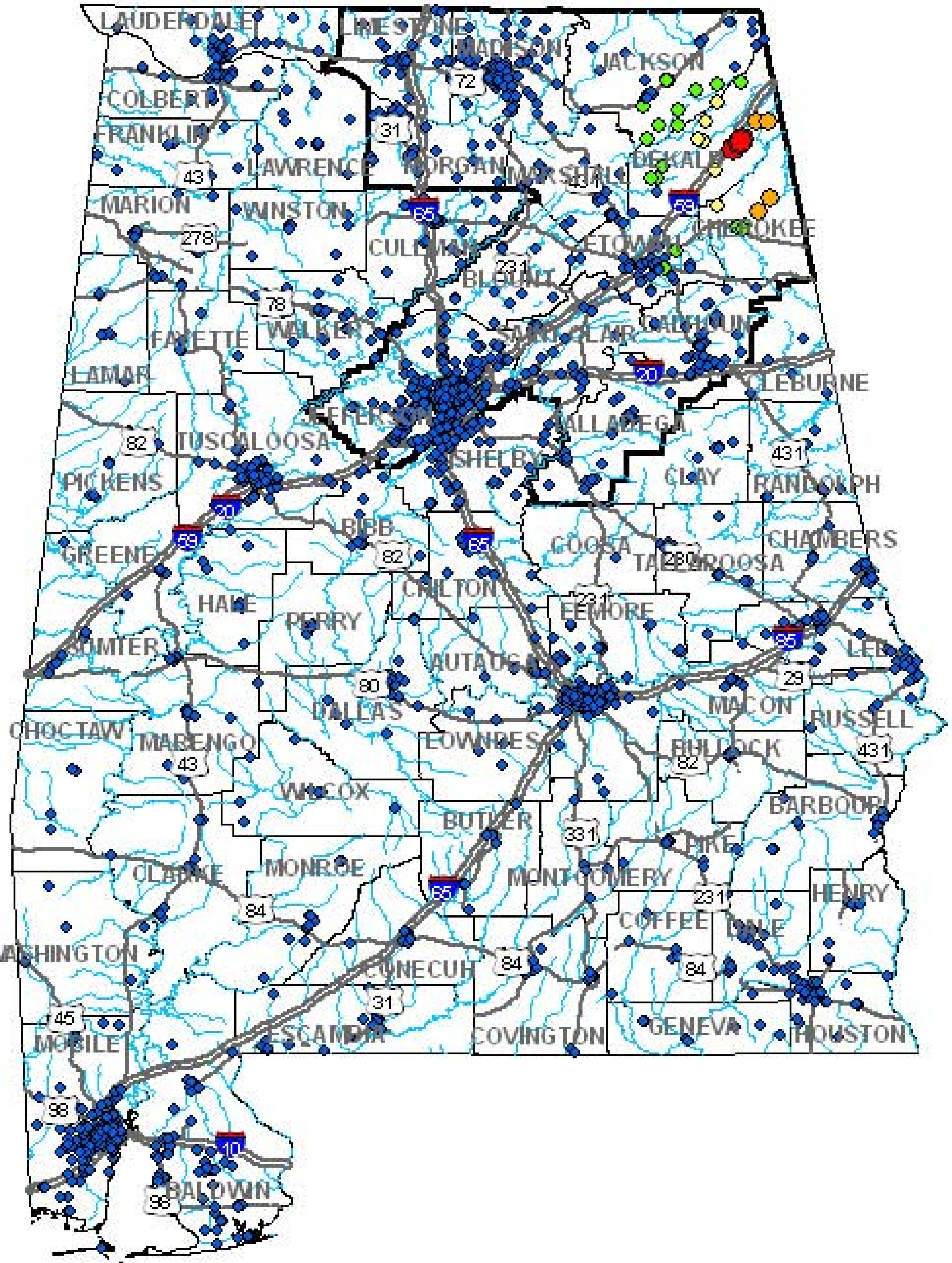
School Damage - School Damage Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	18	0	0
Calhoun	45	0	0
Cherokee	8	2	0
Dekalb	18	6	0
Etowah	46	0	0
Jackson	30	0	0
Jefferson	253	0	0
Limestone	26	0	0
Madison	107	0	0
Marshall	36	0	0
Morgan	46	0	0
Saint Clair	29	0	0
Talladega	36	0	0

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75
Miles

Mid-America Earthquake Center

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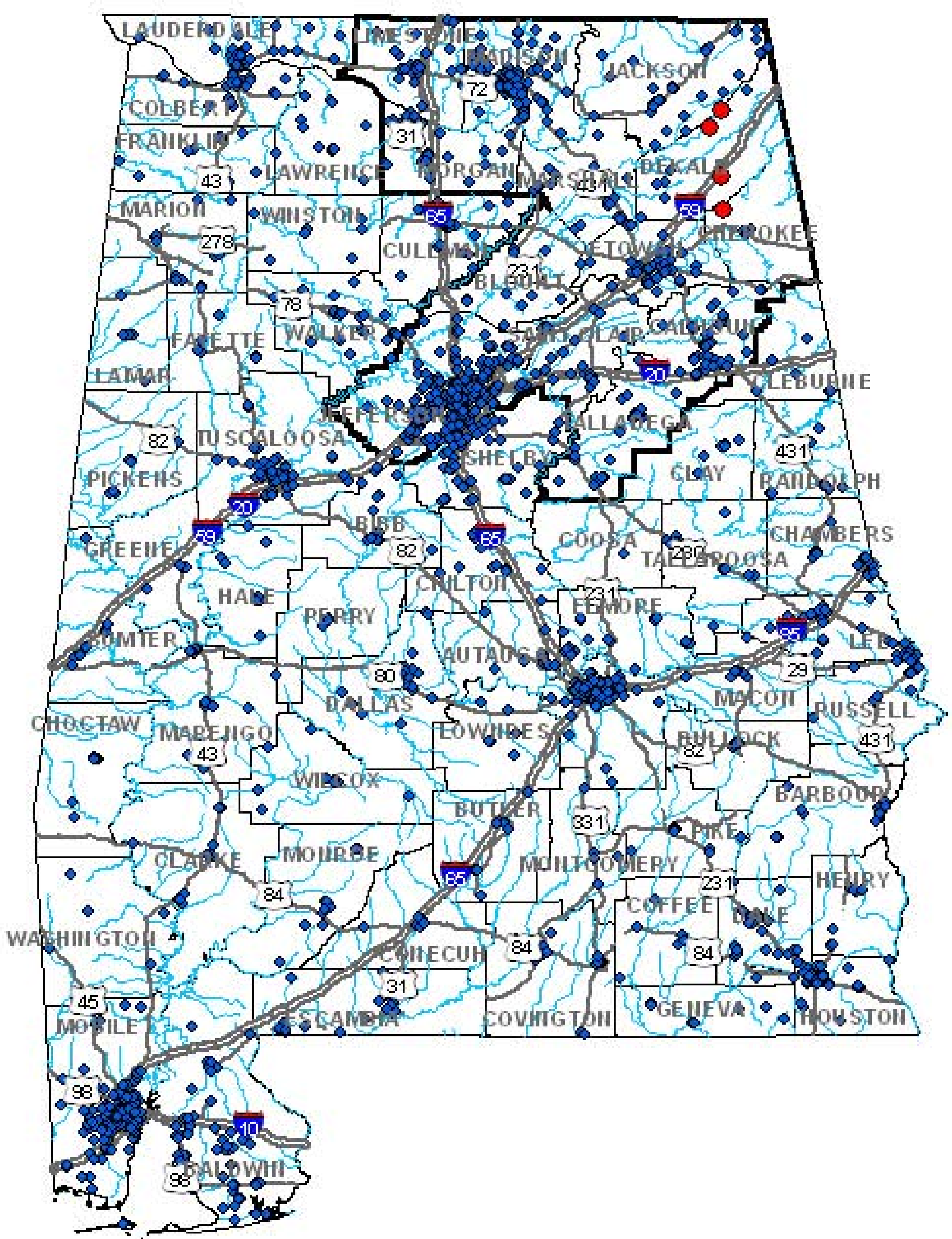
School Functionality - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	No. of Functional Facilities	Total No. of Facilities
Blount	18	18
Calhoun	45	45
Cherokee	5	8
Dekalb	7	18
Etowah	46	46
Jackson	30	30
Jefferson	253	253
Limestone	26	26
Madison	107	107
Marshall	36	36
Morgan	46	46
Saint Clair	29	29
Talladega	36	36

Legend

School Functionality

Day 1

- Not Functional
- Functional
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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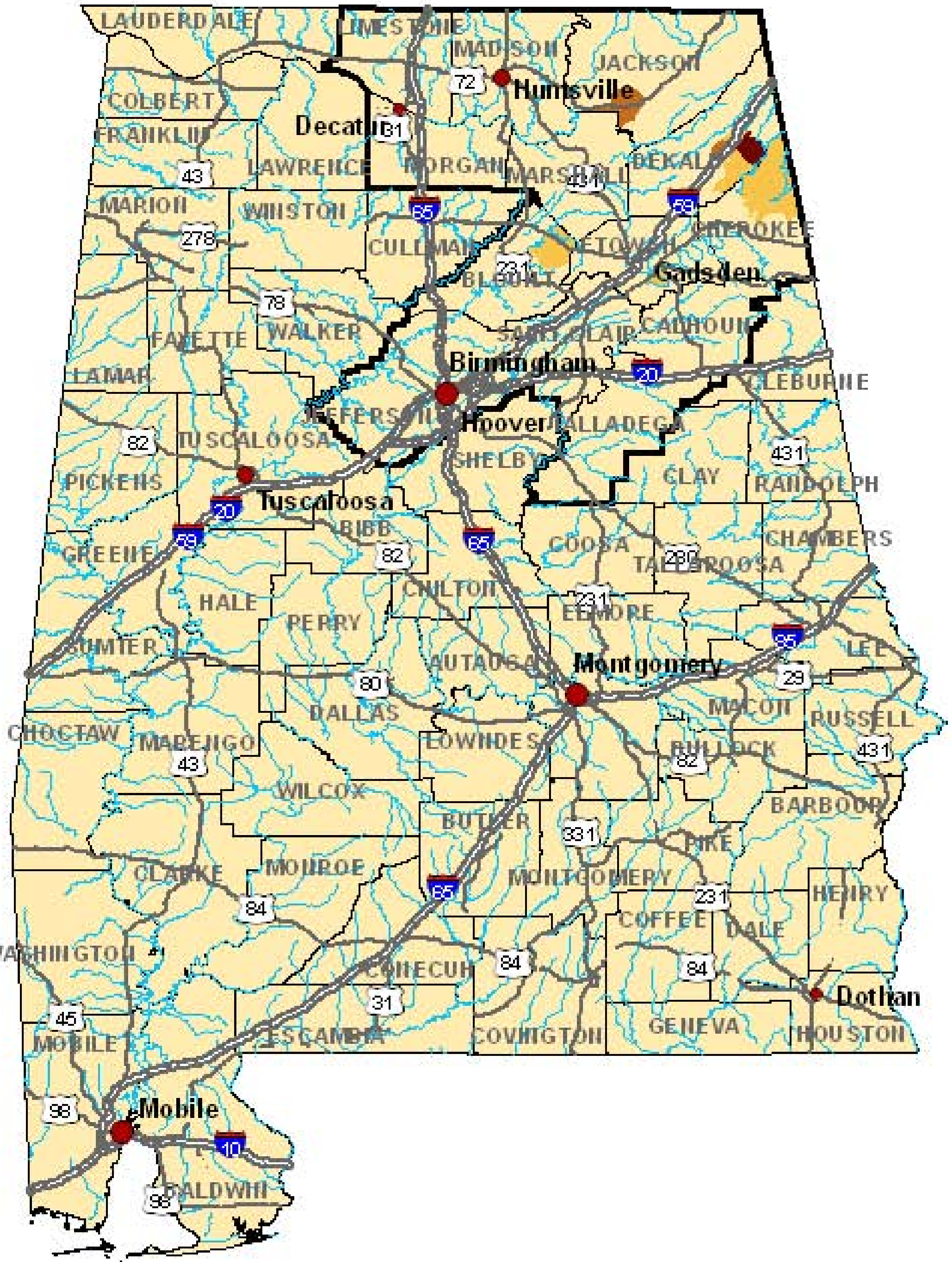
Total Debris - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Brick/ Wood	Concrete/ Steel	Total Debris
Blount	7.74	0.92	8.66
Calhoun	0.77	0.07	0.84
Cherokee	6.82	2.23	9.05
Dekalb	40.74	36.04	76.78
Etowah	13.37	12.21	25.58
Jackson	10.66	9.23	19.89
Jefferson	0.83	0.04	0.87
Limestone	0.12	0.01	0.12
Madison	1.42	0.1	1.52
Marshall	1.23	0.17	1.39
Morgan	0.32	0.02	0.34
Saint Clair	0.3	0.03	0.32
Talladega	0.16	0.01	0.17

Legend

Total Debris

(Thousands of Tons)

- 0 - 5
- 5 - 10
- 10 - 20
- 20 - 35

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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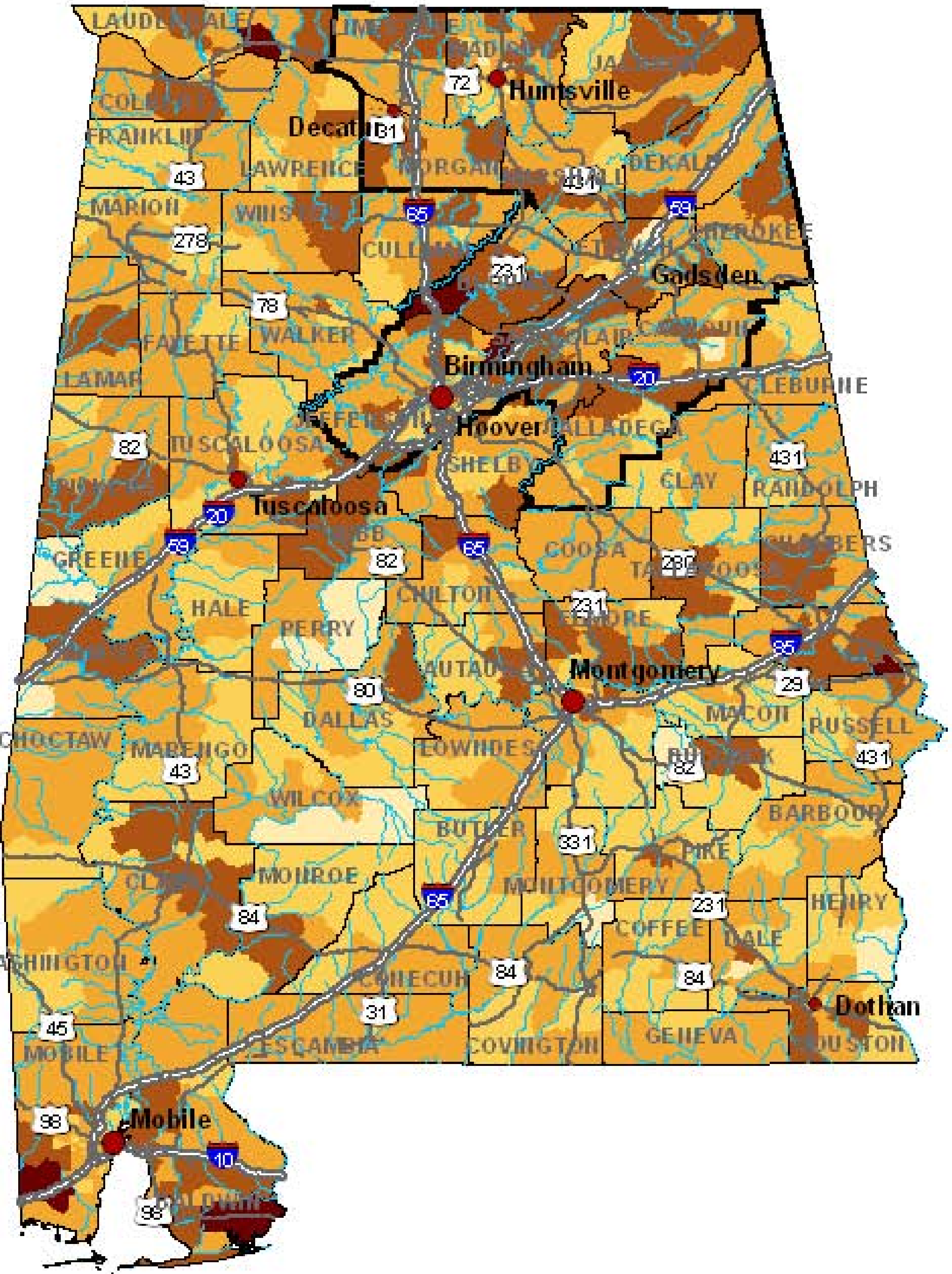
Total Population (2000) - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Population
Blount	51,024
Calhoun	112,249
Cherokee	23,988
Dekalb	64,452
Etowah	103,459
Jackson	53,926
Jefferson	662,047
Limestone	65,676
Madison	276,700
Marshall	82,231
Morgan	111,064
Saint Clair	64,742
Talladega	80,321

Legend

Total Population (2000)

- 0 - 1,500
- 1,501 - 3,000
- 3,001 - 6,000
- 6,001 - 10,000
- 10,001 - 14,710

Major Cities

- 50,000 - 75,000
- 75,001 - 175,000
- 175,001 - 265,000

Rivers
US Routes
Interstates
Critical Counties

0 12.5 25 50 75
Miles

Mid-America Earthquake Center

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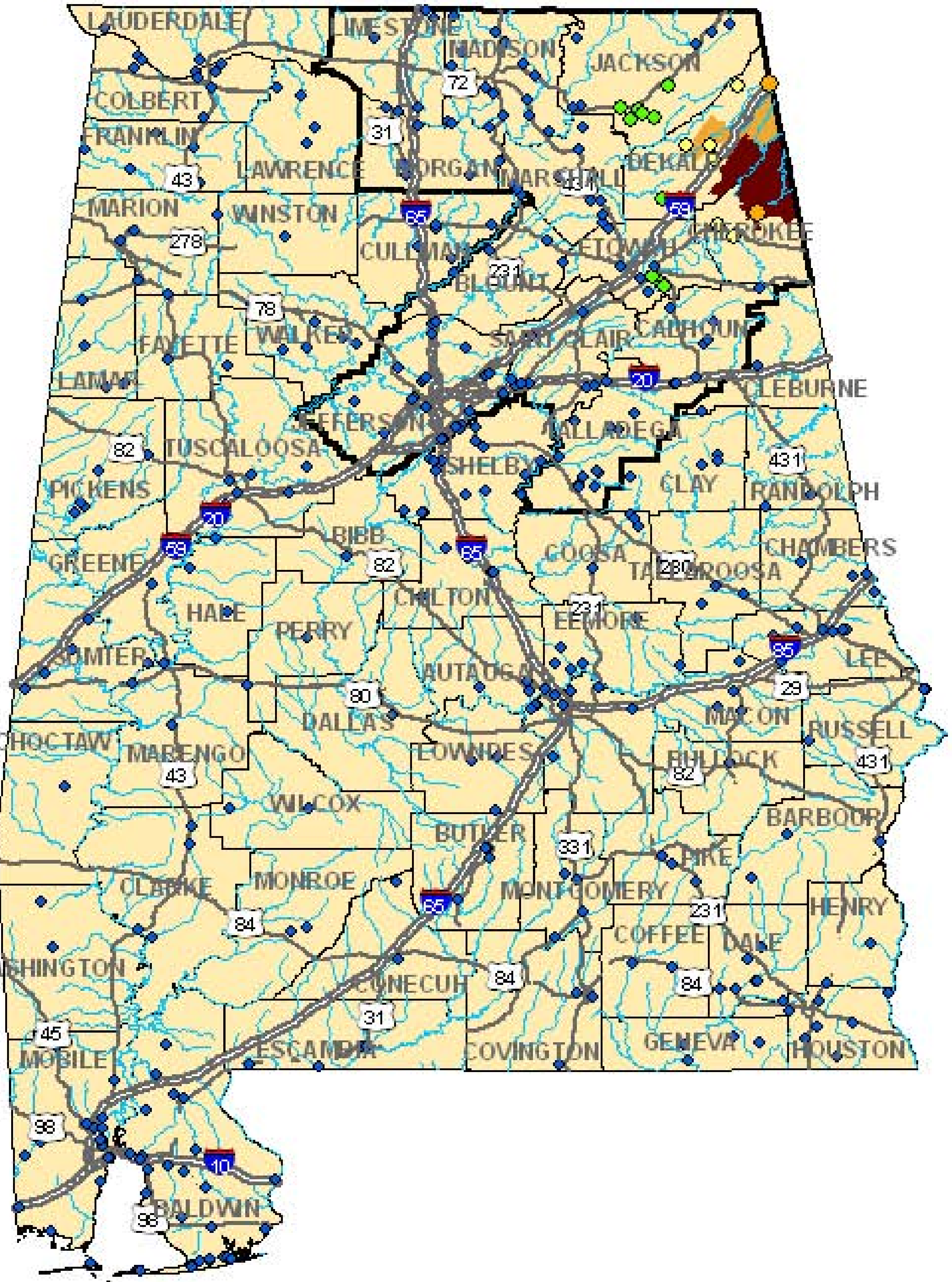
Waste Water Facility Damage - East Tennessee Seismic Zone: M5.9 Event

March 2008



State of Alabama Critical Counties (13)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Blount	3	0	0
Calhoun	6	0	0
Cherokee	3	1	0
Dekalb	7	1	0
Etowah	9	0	0
Jackson	12	0	0
Jefferson	20	0	0
Limestone	5	0	0
Madison	16	0	0
Marshall	16	0	0
Morgan	8	0	0
Saint Clair	8	0	0
Talladega	17	0	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Waste Water Distribution Lines

No. Leaks

- 0 - 5
- 5 - 10
- 10 - 25
- Rivers
- US Routes
- Interstates
- Critical Counties

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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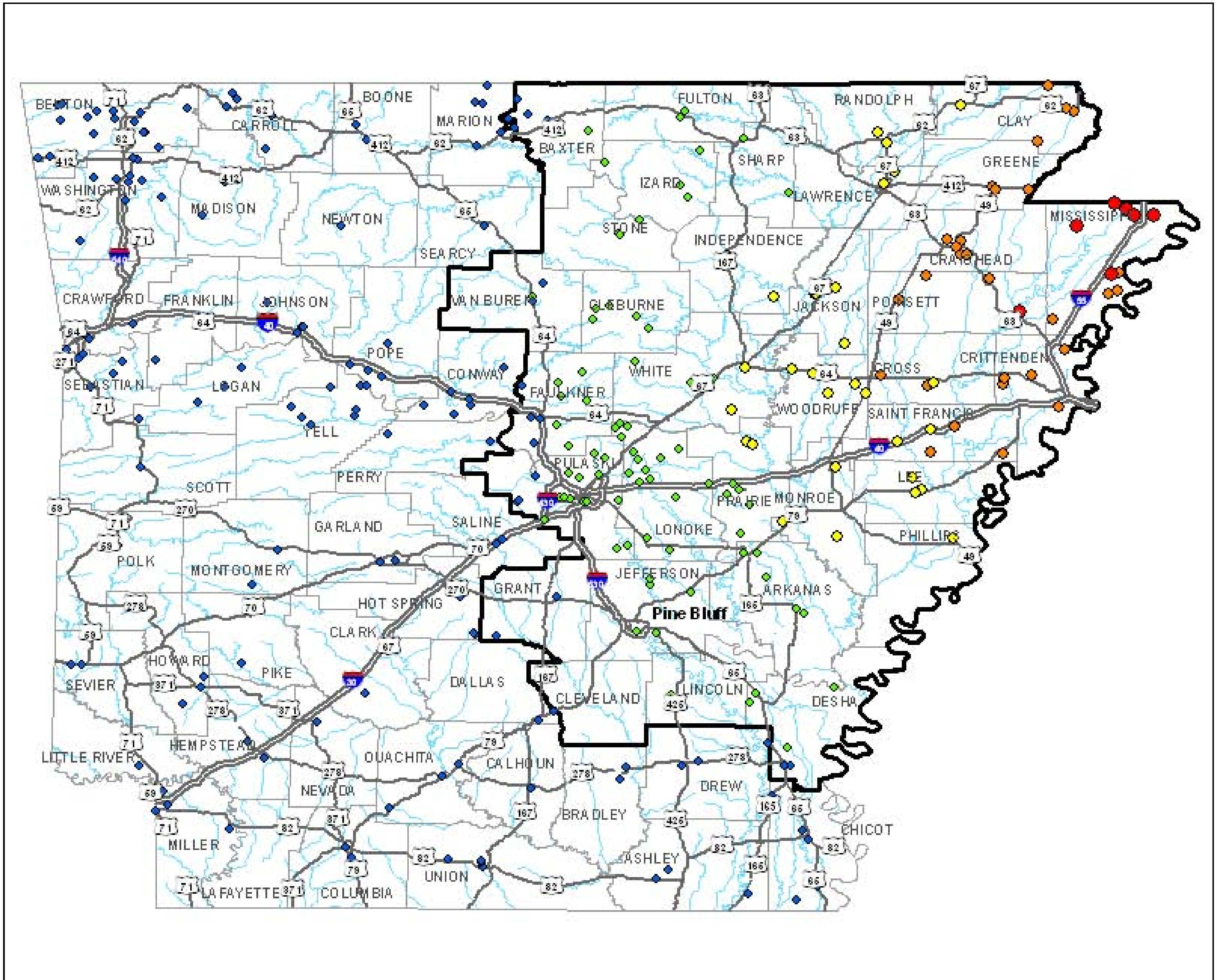
Airport Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	5	0	0
Baxter	6	0	0
Clay	5	4	0
Cleburne	5	0	0
Cleveland	0	0	0
Craighead	5	5	0
Crittenden	5	5	0
Cross	3	2	0
Desha	6	0	0
Faulkner	12	0	0
Fulton	2	0	0
Grant	2	0	0
Greene	3	3	0
Independence	3	0	0
Izard	5	0	0
Jackson	4	0	0
Jefferson	5	0	0
Lawrence	2	0	0
Lee	3	0	0
Lincoln	1	0	0
Lonoke	15	0	0
Mississippi	10	10	4
Monroe	3	0	0
Phillips	2	0	0
Poinsett	4	4	1
Prairie	7	0	0
Pulaski	21	0	0
Randolph	2	0	0
Saint Francis	5	3	0
Sharp	2	0	0
Stone	2	0	0
Van Buren	3	0	0
White	8	0	0
Woodruff	6	0	0

Legend

Airport Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Critical Counties

Interstate Highways

US Routes

Rivers

0 10 20 40 60

Miles

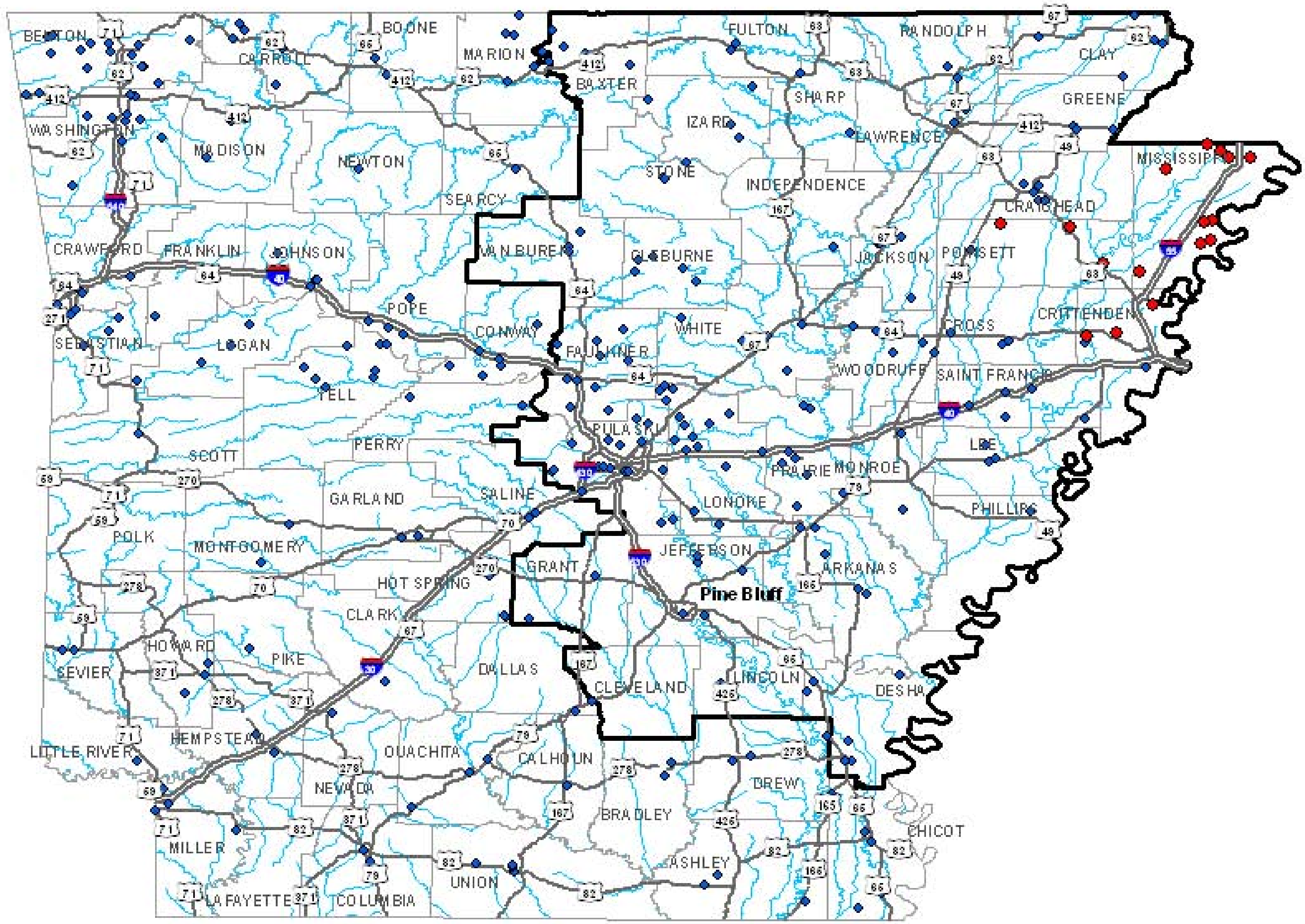
Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Airport Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	5	5
Baxter	6	6
Clay	5	5
Cleburne	5	5
Cleveland	0	0
Craighead	5	5
Crittenden	2	5
Cross	3	3
Desha	6	6
Faulkner	12	12
Fulton	2	2
Grant	2	2
Greene	3	3
Independence	3	3
Izard	5	5
Jackson	4	4
Jefferson	5	5
Lawrence	2	2
Lee	3	3
Lincoln	1	1
Lonoke	15	15
Mississippi	0	10
Monroe	3	3
Phillips	2	2
Poinsett	1	4
Prairie	7	7
Pulaski	21	21
Randolph	2	2
Saint Francis	5	5
Sharp	2	2
Stone	2	2
Van Buren	3	3
White	8	8
Woodruff	6	6

Legend

Airport Facility Functionality

Day 1

- Not Functional
- Functional
- Interstate Highways
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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Mid-America Earthquake Center

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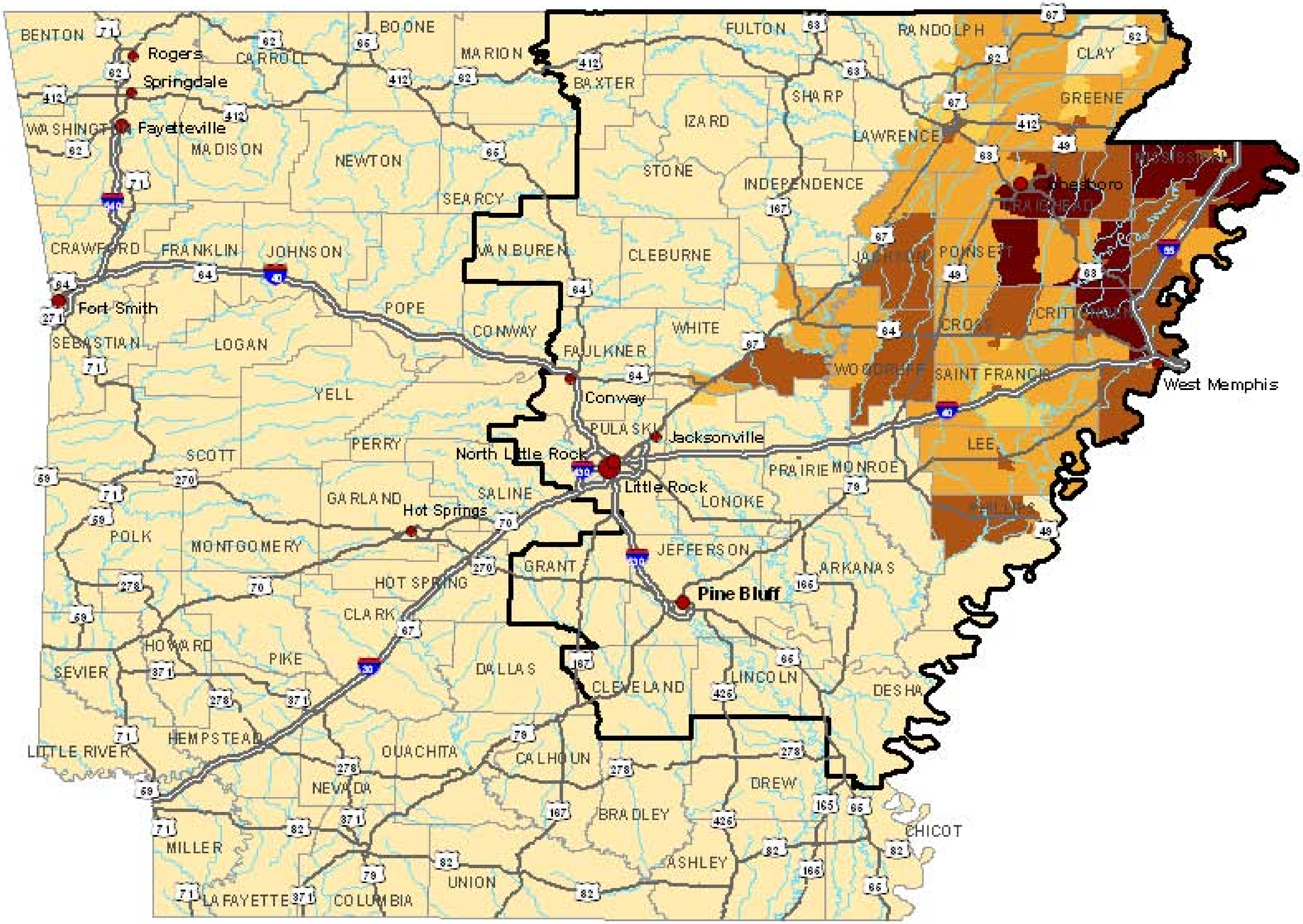
Worst Case Casualties (2AM) - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Arkansas	46	2	48
Baxter	0	0	0
Clay	272	16	287
Cleburne	1	0	1
Cleveland	1	0	1
Craighead	3,068	205	3,273
Crittenden	1,515	96	1,611
Cross	448	27	476
Desha	2	0	2
Faulkner	1	0	1
Fulton	0	0	0
Grant	1	0	1
Greene	614	36	649
Independence	8	0	8
Izard	0	0	0
Jackson	335	19	354
Jefferson	17	0	17
Lawrence	175	10	185
Lee	207	11	218
Lincoln	3	0	3
Lonoke	41	2	43
Mississippi	2,785	182	2,967
Monroe	40	2	42
Phillips	301	17	318
Poinsett	927	59	985
Prairie	17	1	18
Pulaski	96	0	96
Randolph	86	4	90
Saint Francis	401	22	423
Sharp	3	0	3
Stone	0	0	0
Van Buren	0	0	0
White	388	23	411
Woodruff	144	8	151

Legend

Worst Case Casualties

2AM

- 0 - 50
- 51 - 100
- 101 - 250
- 251 - 500
- 501 - 960
- US Routes
- Interstate Highways
- Critical Counties
- Rivers

Major Cities

Population in 2000

- 28,000 - 40,000
- 40,001 - 75,000
- 75,001 - 180,000

0 10 20 40 60

Miles

Mid-America Earthquake Center

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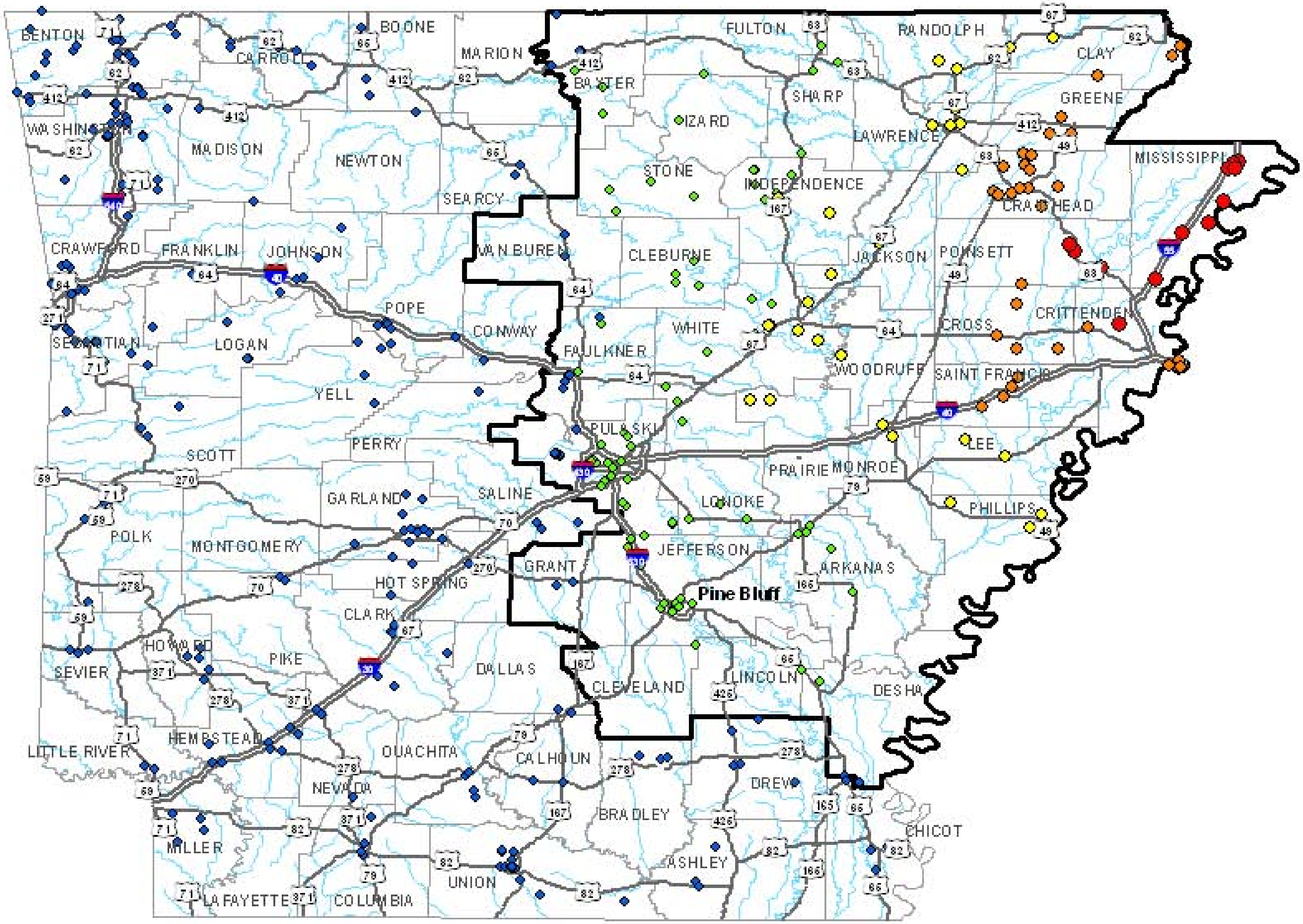
Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	8	0	0
Baxter	12	0	0
Clay	5	3	0
Cleburne	4	0	0
Cleveland	0	0	0
Craighead	18	18	0
Crittenden	9	9	0
Cross	4	4	0
Desha	4	0	0
Faulkner	8	0	0
Fulton	2	0	0
Grant	9	0	0
Greene	4	4	0
Independence	29	0	0
Izard	2	0	0
Jackson	2	0	0
Jefferson	23	0	0
Lawrence	8	0	0
Lee	2	0	0
Lincoln	1	0	0
Lonoke	6	0	0
Mississippi	12	12	5
Monroe	2	0	0
Phillips	7	0	0
Poinsett	5	5	0
Prairie	2	0	0
Pulaski	62	0	0
Randolph	4	0	0
Saint Francis	4	4	0
Sharp	3	0	0
Stone	8	0	0
Van Buren	3	0	0
White	11	0	0
Woodruff	1	0	0

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Critical Counties
Interstate Highways
US Routes
Rivers

0 10 20 40 60
Miles

Mid-America Earthquake Center

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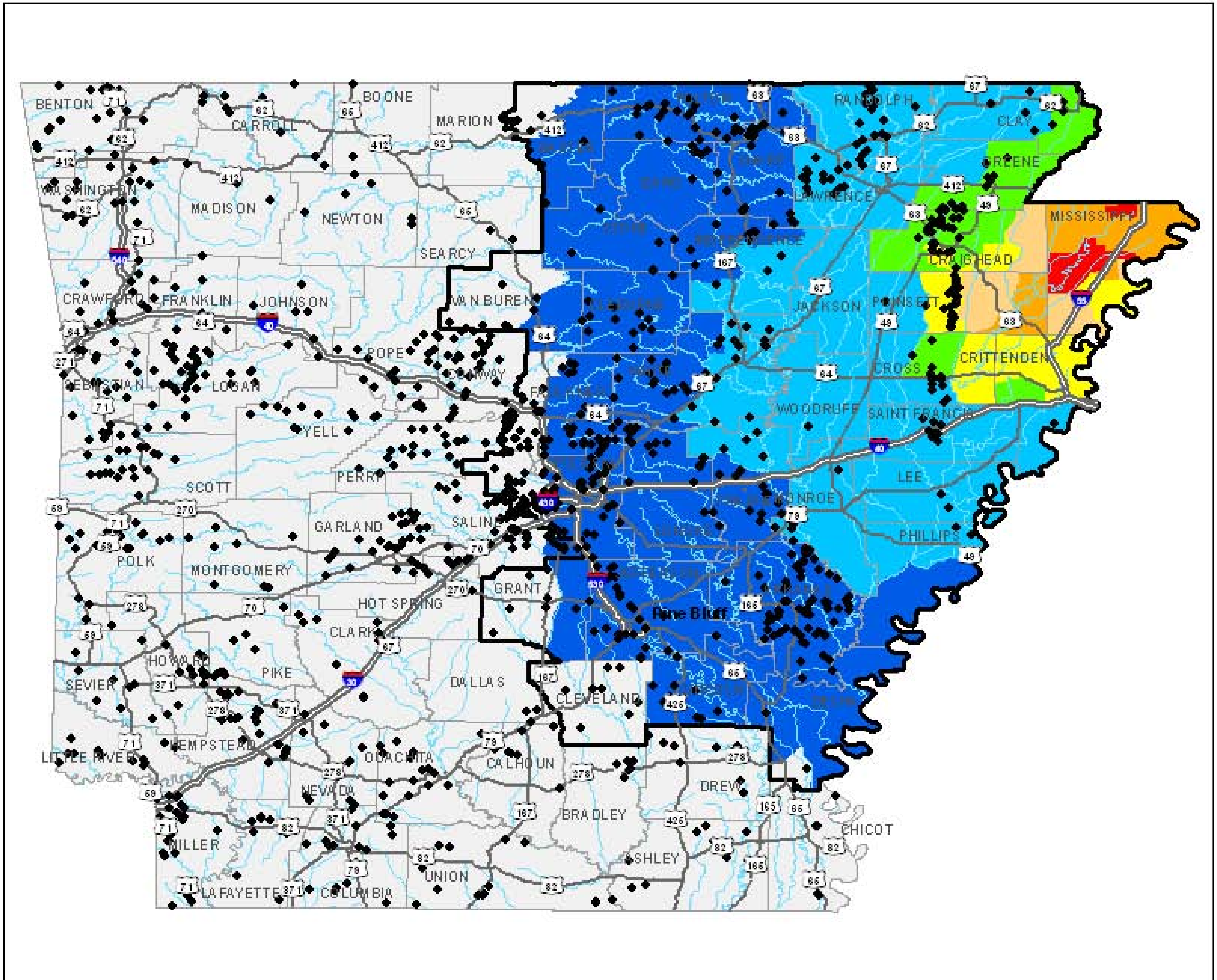
Dams - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Facilities
Arkansas	71
Baxter	7
Clay	10
Cleburne	14
Cleveland	8
Craighead	27
Crittenden	1
Cross	15
Desha	2
Faulkner	36
Fulton	24
Grant	8
Greene	12
Independence	11
Izard	7
Jackson	2
Jefferson	27
Lawrence	17
Lee	2
Lincoln	10
Lonoke	23
Mississippi	0
Monroe	5
Phillips	3
Poinsett	27
Prairie	19
Pulaski	89
Randolph	20
Saint Francis	9
Sharp	24
Stone	5
Van Buren	9
White	30
Woodruff	1

Legend

- Dams
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

MMI

- <VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

0 10 20 40 60

Miles

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Mid-America Earthquake Center

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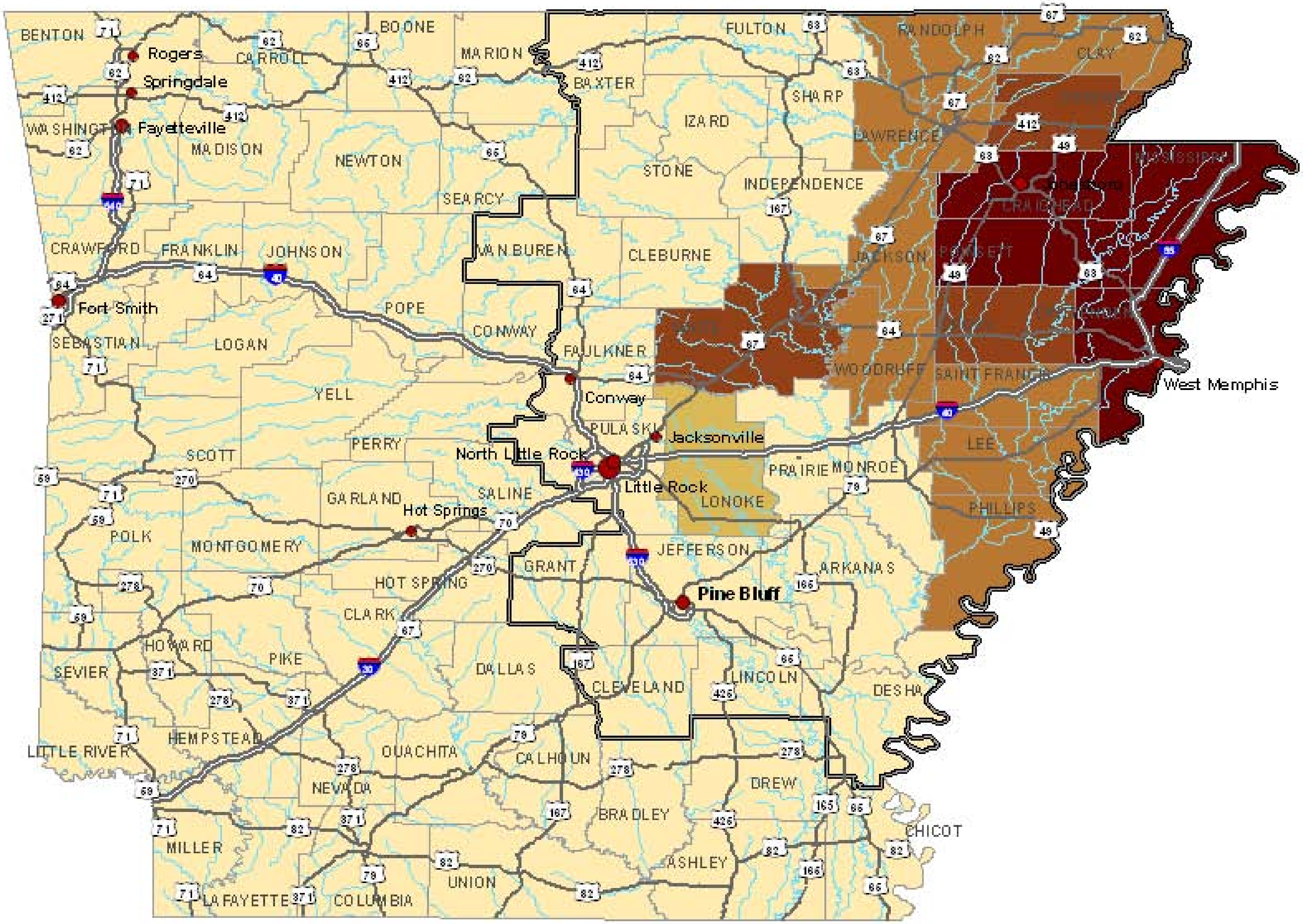
Displaced Population - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Displaced Residences	Estimate of Displaced Population
Arkansas	74	182
Baxter	0	0
Clay	1,285	3,051
Cleburne	0	0
Cleveland	0	0
Craighead	8,064	20,510
Crittenden	6,250	17,210
Cross	2,349	6,204
Desha	0	1
Faulkner	0	0
Fulton	0	0
Grant	0	0
Greene	2,628	6,651
Independence	0	1
Izard	0	0
Jackson	1,670	4,413
Jefferson	2	6
Lawrence	1,163	2,907
Lee	1,116	3,356
Lincoln	0	0
Lonoke	190	522
Mississippi	11,507	30,911
Monroe	79	198
Phillips	1,680	4,574
Poinsett	4,795	12,249
Prairie	57	139
Pulaski	22	55
Randolph	521	1,305
Saint Francis	1,535	4,484
Sharp	0	0
Stone	0	0
Van Buren	0	0
White	2,151	5,745
Woodruff	934	2,313

Legend

Displaced Population

- 0 - 250
- 251 - 1,000
- 1,001 - 5,000
- 5,001 - 10,000
- 10,001 - 30,911

Major Cities

Population in 2000

- 28,000 - 40,000
- 40,001 - 75,000
- 75,001 - 180,000

- US Routes
- Interstate Highways
- Critical Counties
- Rivers

0 10 20 40 60
Miles

Mid-America Earthquake Center
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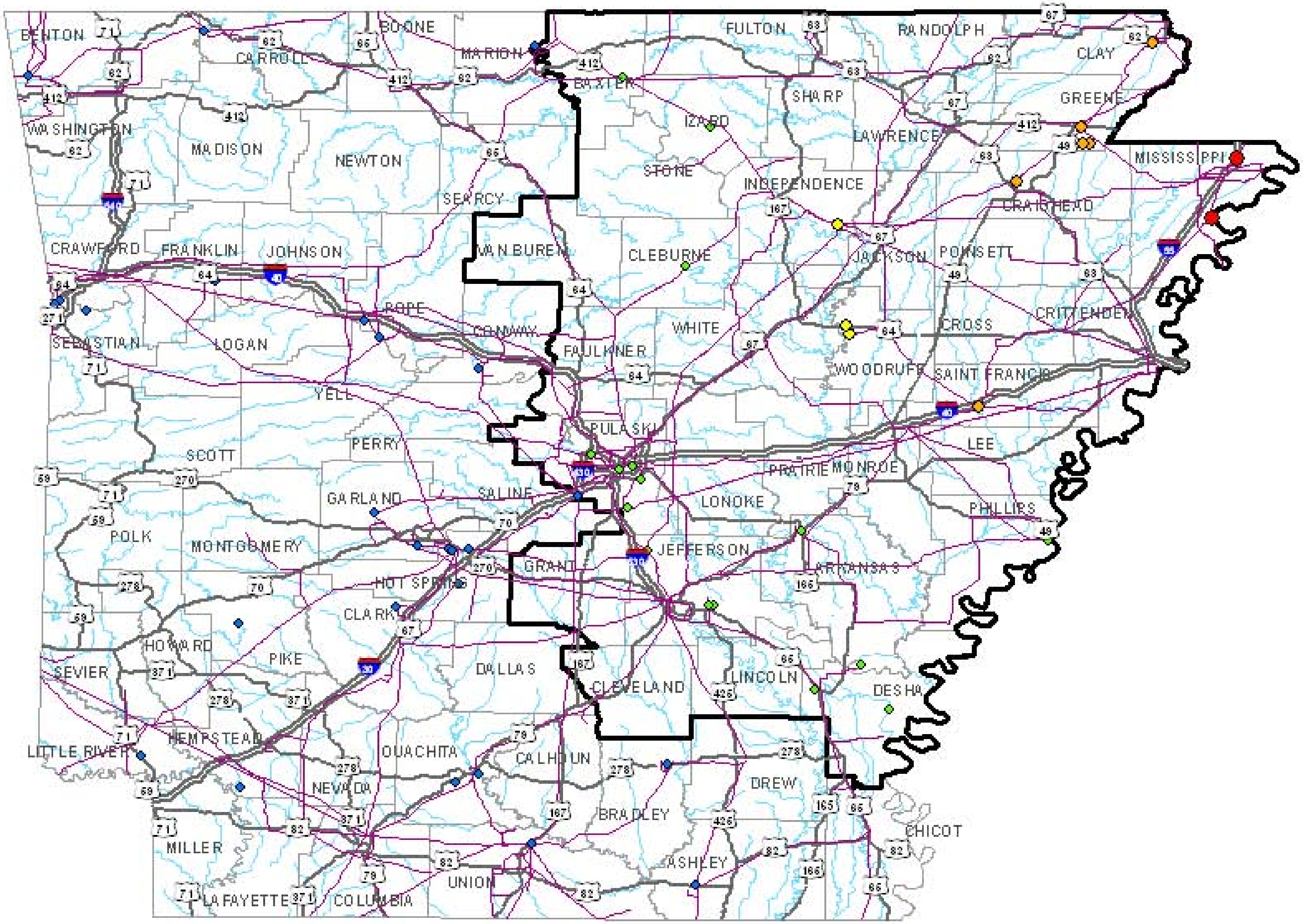
Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	1	0	0
Baxter	1	0	0
Clay	1	1	0
Cleburne	1	0	0
Cleveland	0	0	0
Craighead	1	1	0
Crittenden	0	0	0
Cross	0	0	0
Desha	3	0	0
Faulkner	0	0	0
Fulton	0	0	0
Grant	0	0	0
Greene	3	3	0
Independence	1	0	0
Izard	1	0	0
Jackson	0	0	0
Jefferson	3	0	0
Lawrence	0	0	0
Lee	0	0	0
Lincoln	0	0	0
Lonoke	0	0	0
Mississippi	2	2	1
Monroe	0	0	0
Phillips	1	0	0
Poinsett	0	0	0
Prairie	0	0	0
Pulaski	6	0	0
Randolph	0	0	0
Saint Francis	1	1	0
Sharp	0	0	0
Stone	0	0	0
Van Buren	0	0	0
White	1	0	0
Woodruff	2	0	0

Legend

Electric Power Facility Damage

At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Electric Transmission Lines
Critical Counties
Interstate Highways
US Routes
Rivers

0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

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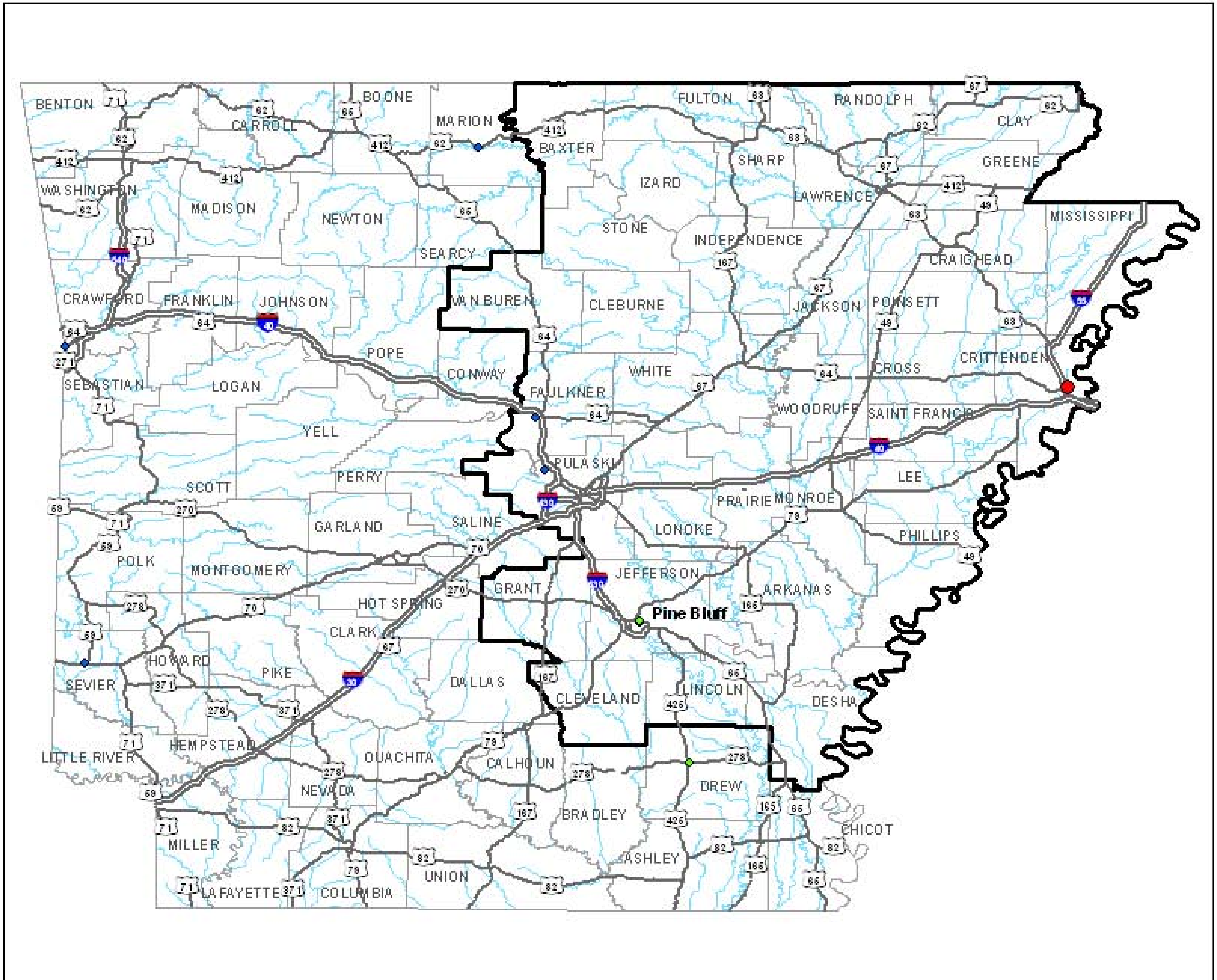
Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Crittenden	1	1	1
Faulkner	1	0	0
Jefferson	2	0	0
Pulaski	1	0	0
Arkansas	0	0	0
Baxter	0	0	0
Clay	0	0	0
Cleburne	0	0	0
Cleveland	0	0	0
Craighead	0	0	0
Cross	0	0	0
Desha	0	0	0
Fulton	0	0	0
Grant	0	0	0
Greene	0	0	0
Independence	0	0	0
Izard	0	0	0
Jackson	0	0	0
Lawrence	0	0	0
Lee	0	0	0
Lincoln	0	0	0
Lonoke	0	0	0
Mississippi	0	0	0
Monroe	0	0	0
Phillips	0	0	0
Poinsett	0	0	0
Prairie	0	0	0
Randolph	0	0	0
Saint Francis	0	0	0
Sharp	0	0	0
Stone	0	0	0
Van Buren	0	0	0
White	0	0	0
Woodruff	0	0	0

Legend

Emergency Operation Centers

At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Critical Counties

Interstate Highways

US Routes

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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Theresa Jefferson, Principal Investigator

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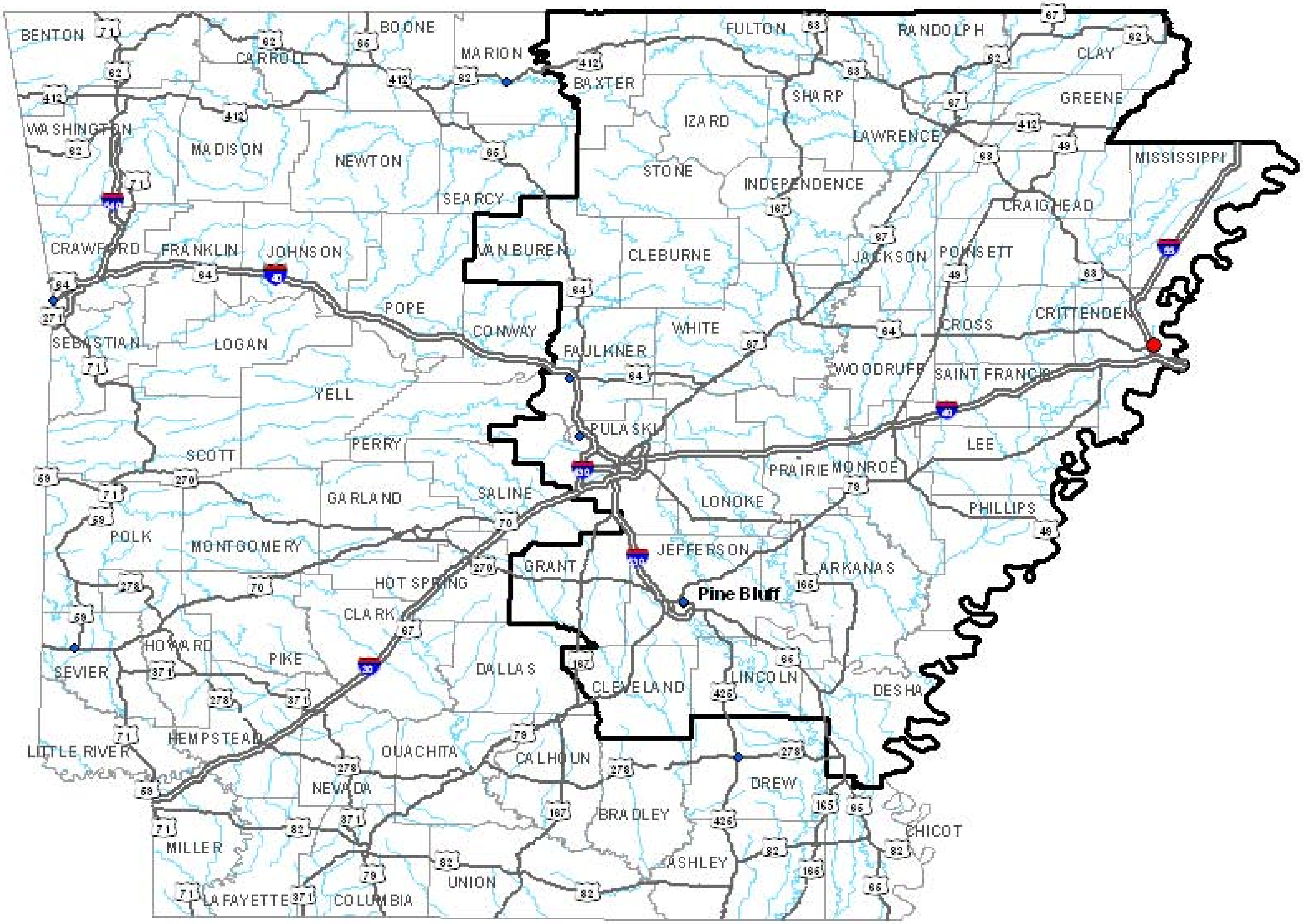
EOC Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	0	0
Baxter	0	0
Clay	0	0
Cleburne	0	0
Cleveland	0	0
Craighead	0	0
Crittenden	0	1
Cross	0	0
Desha	0	0
Faulkner	1	1
Fulton	0	0
Grant	0	0
Greene	0	0
Independence	0	0
Izard	0	0
Jackson	0	0
Jefferson	2	2
Lawrence	0	0
Lee	0	0
Lincoln	0	0
Lonoke	0	0
Mississippi	0	0
Monroe	0	0
Phillips	0	0
Poinsett	0	0
Prairie	0	0
Pulaski	1	1
Randolph	0	0
Saint Francis	0	0
Sharp	0	0
Stone	0	0
Van Buren	0	0
White	0	0
Woodruff	0	0

Legend

Emergency Operation Centers

Functionality at Day 1

- Not Functional
- Functional
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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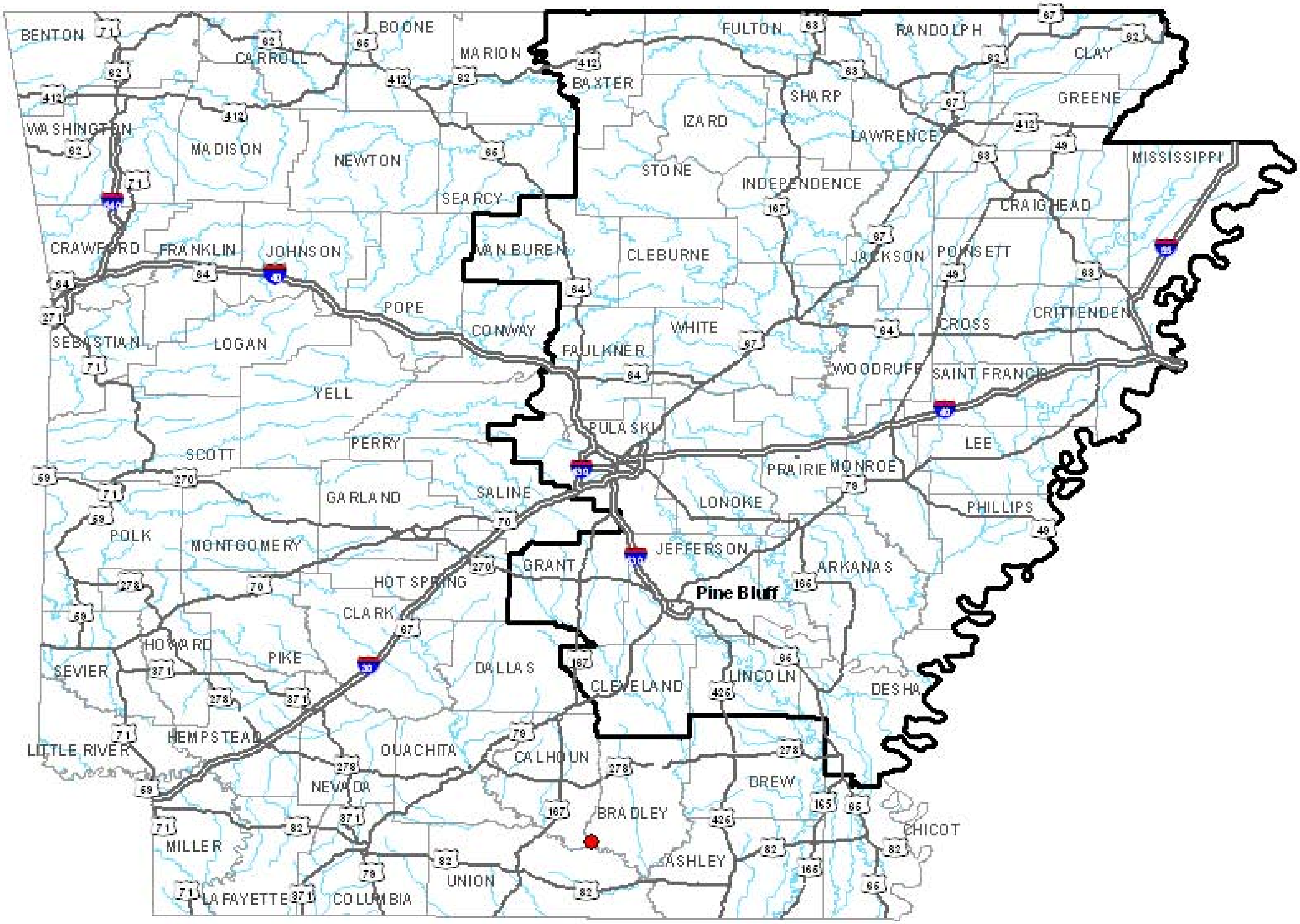
Ferry Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	0	0	0
Baxter	0	0	0
Clay	0	0	0
Cleburne	0	0	0
Cleveland	0	0	0
Craighead	0	0	0
Crittenden	0	0	0
Cross	0	0	0
Desha	0	0	0
Faulkner	0	0	0
Fulton	0	0	0
Grant	0	0	0
Greene	0	0	0
Independence	0	0	0
Izard	0	0	0
Jackson	0	0	0
Jefferson	0	0	0
Lawrence	0	0	0
Lee	0	0	0
Lincoln	0	0	0
Lonoke	0	0	0
Mississippi	0	0	0
Monroe	0	0	0
Phillips	0	0	0
Poinsett	0	0	0
Prairie	0	0	0
Pulaski	0	0	0
Randolph	0	0	0
Saint Francis	0	0	0
Sharp	0	0	0
Stone	0	0	0
Van Buren	0	0	0
White	0	0	0
Woodruff	0	0	0

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Interstate Highways

US Routes

Rivers

Critical Counties

0 10 20 40 60

Miles

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Mid-America Earthquake Center
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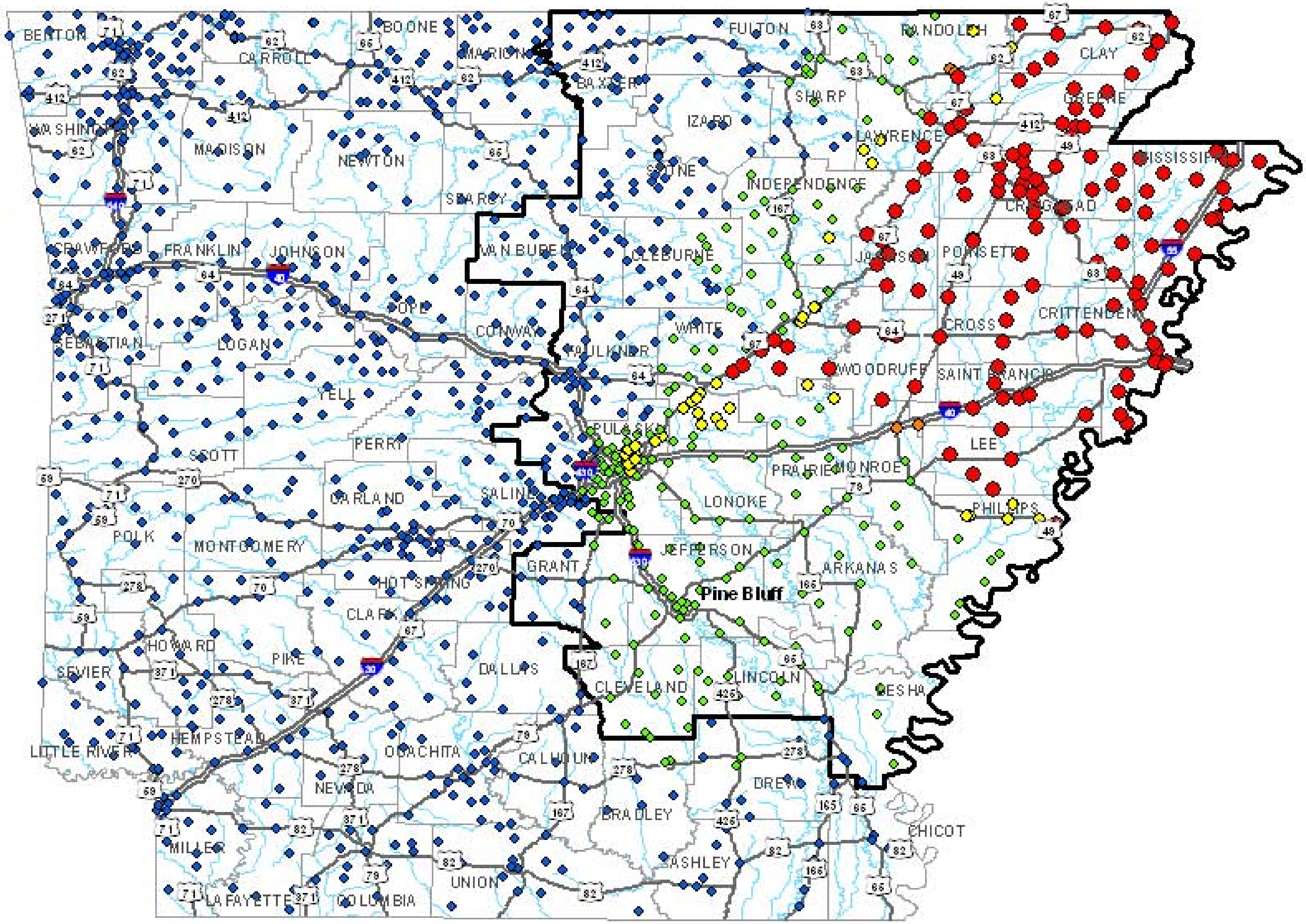
Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas
Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	13	0	0
Baxter	25	0	0
Clay	11	11	3
Cleburne	19	0	0
Cleveland	10	0	0
Craighead	24	24	17
Crittenden	17	17	9
Cross	7	7	4
Desha	9	0	0
Faulkner	28	0	0
Fulton	13	0	0
Grant	11	0	0
Greene	11	11	5
Independence	19	0	0
Izard	12	0	0
Jackson	12	12	0
Jefferson	23	0	0
Lawrence	14	7	0
Lee	6	6	0
Lincoln	11	0	0
Lonoke	23	0	0
Mississippi	19	19	19
Monroe	7	1	0
Phillips	12	1	0
Poinsett	9	9	6
Prairie	14	0	0
Pulaski	68	0	0
Randolph	11	3	0
Saint Francis	8	8	0
Sharp	17	0	0
Stone	22	0	0
Van Buren	24	0	0
White	40	9	0
Woodruff	6	6	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Critical Counties

Interstate Highways

US Routes

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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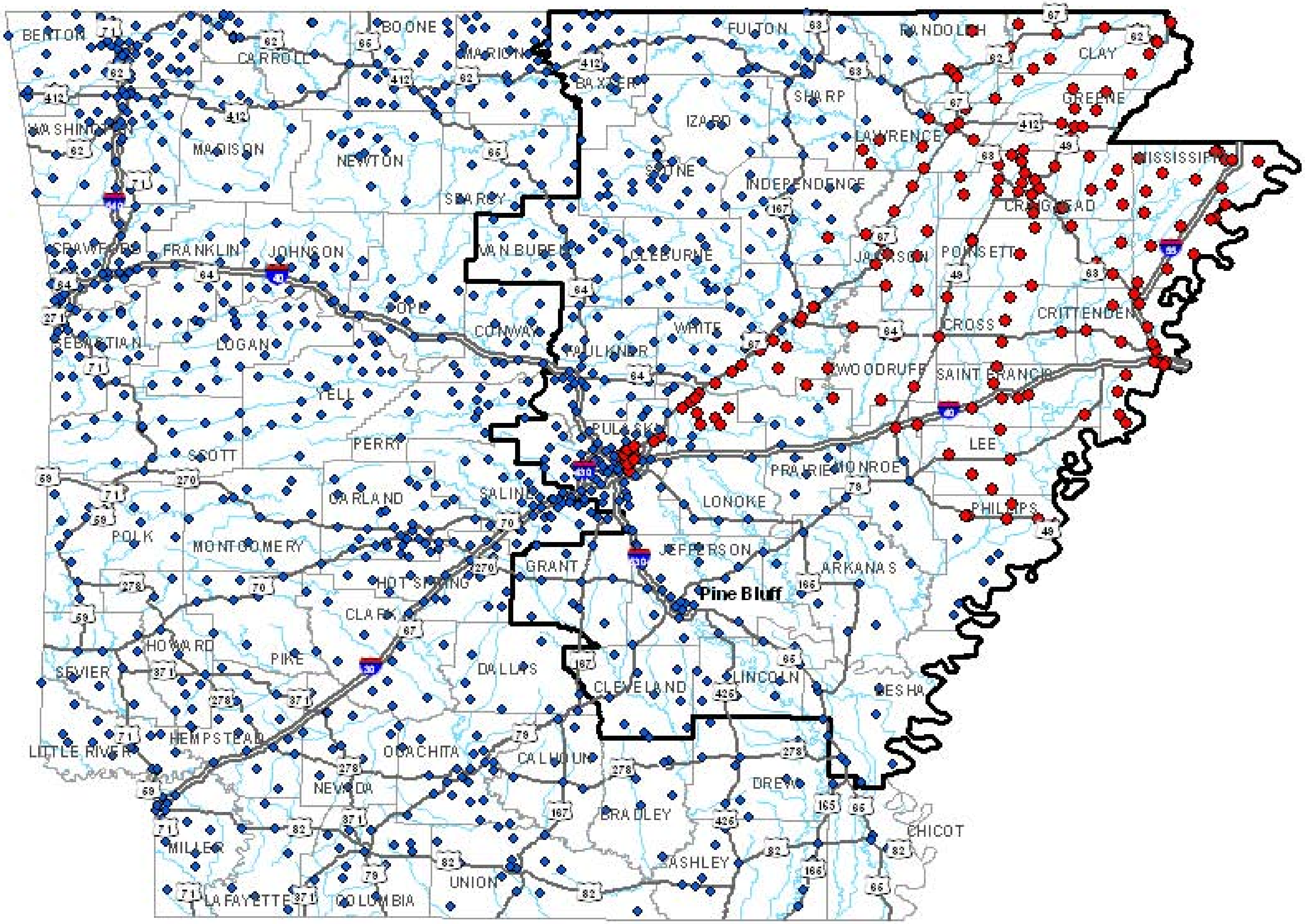
Fire Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	13	13
Baxter	25	25
Clay	0	11
Cleburne	19	19
Cleveland	10	10
Craighead	0	24
Crittenden	0	17
Cross	0	7
Desha	9	9
Faulkner	28	28
Fulton	13	13
Grant	11	11
Greene	0	11
Independence	18	19
Izard	12	12
Jackson	0	12
Jefferson	23	23
Lawrence	4	14
Lee	0	6
Lincoln	11	11
Lonoke	13	23
Mississippi	0	19
Monroe	6	7
Phillips	6	12
Poinsett	0	9
Prairie	12	14
Pulaski	58	68
Randolph	4	11
Saint Francis	0	8
Sharp	17	17
Stone	22	22
Van Buren	24	24
White	26	40
Woodruff	0	6

Legend

Fire Station Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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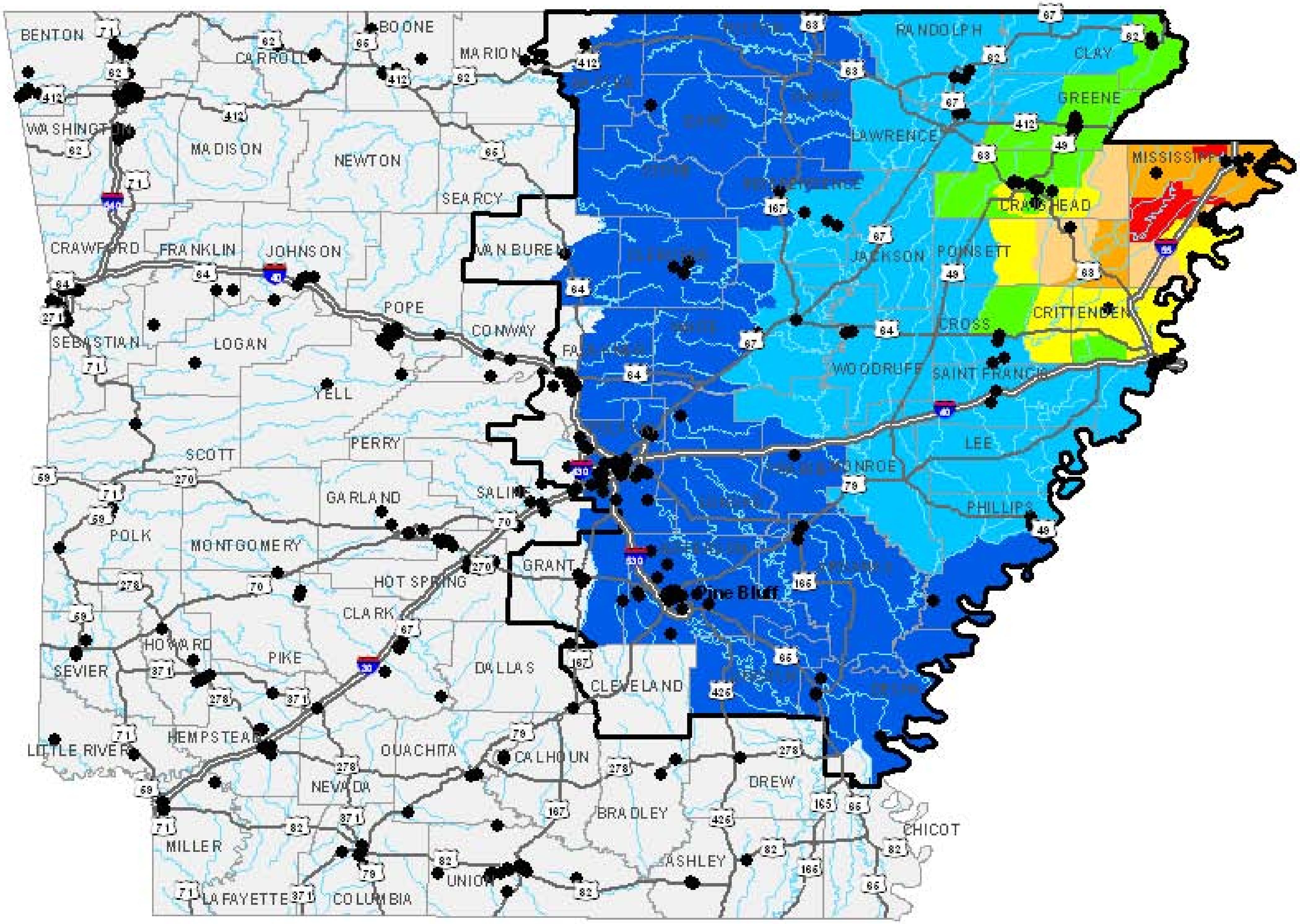
Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Facilities
Arkansas	4
Baxter	16
Clay	4
Cleburne	8
Cleveland	0
Craighead	21
Crittenden	43
Cross	12
Desha	20
Faulkner	34
Fulton	0
Grant	10
Greene	21
Independence	56
Izard	3
Jackson	2
Jefferson	76
Lawrence	2
Lee	0
Lincoln	0
Lonoke	4
Mississippi	65
Monroe	0
Phillips	64
Poinsett	1
Prairie	2
Pulaski	109
Randolph	9
Saint Francis	9
Sharp	0
Stone	0
Van Buren	2
White	19
Woodruff	4

Legend

- Hazardous Materials Facilities
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

MMI
- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

0 10 20 40 60
Miles

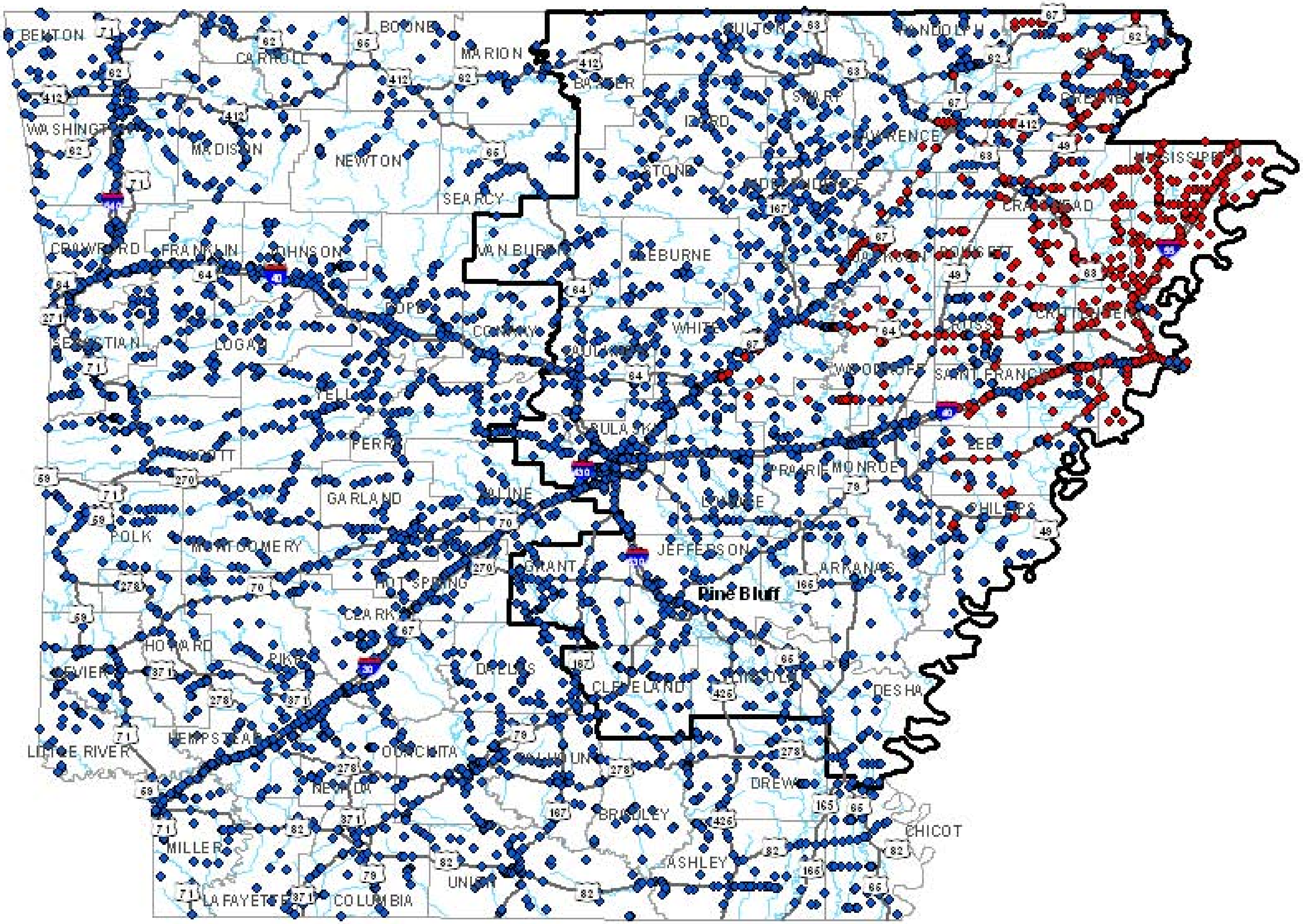
Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Highway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	61	61
Baxter	24	24
Clay	47	70
Cleburne	31	31
Cleveland	61	61
Craighead	49	124
Crittenden	31	147
Cross	42	83
Desha	37	37
Faulkner	90	90
Fulton	55	55
Grant	74	74
Greene	49	79
Independence	130	130
Izard	60	60
Jackson	38	71
Jefferson	92	92
Lawrence	55	68
Lee	32	43
Lincoln	40	40
Lonoke	117	117
Mississippi	0	147
Monroe	73	73
Phillips	41	45
Poinsett	10	95
Prairie	57	64
Pulaski	332	332
Randolph	63	67
Saint Francis	54	120
Sharp	63	63
Stone	40	40
Van Buren	48	48
White	169	181
Woodruff	32	51

Legend

Highway Bridge Functionality

Day 1

- Not Functional
- Functional
- Interstate Highways
- US Routes
- Rivers
- Critical Counties

0 10 20 40 60

Miles

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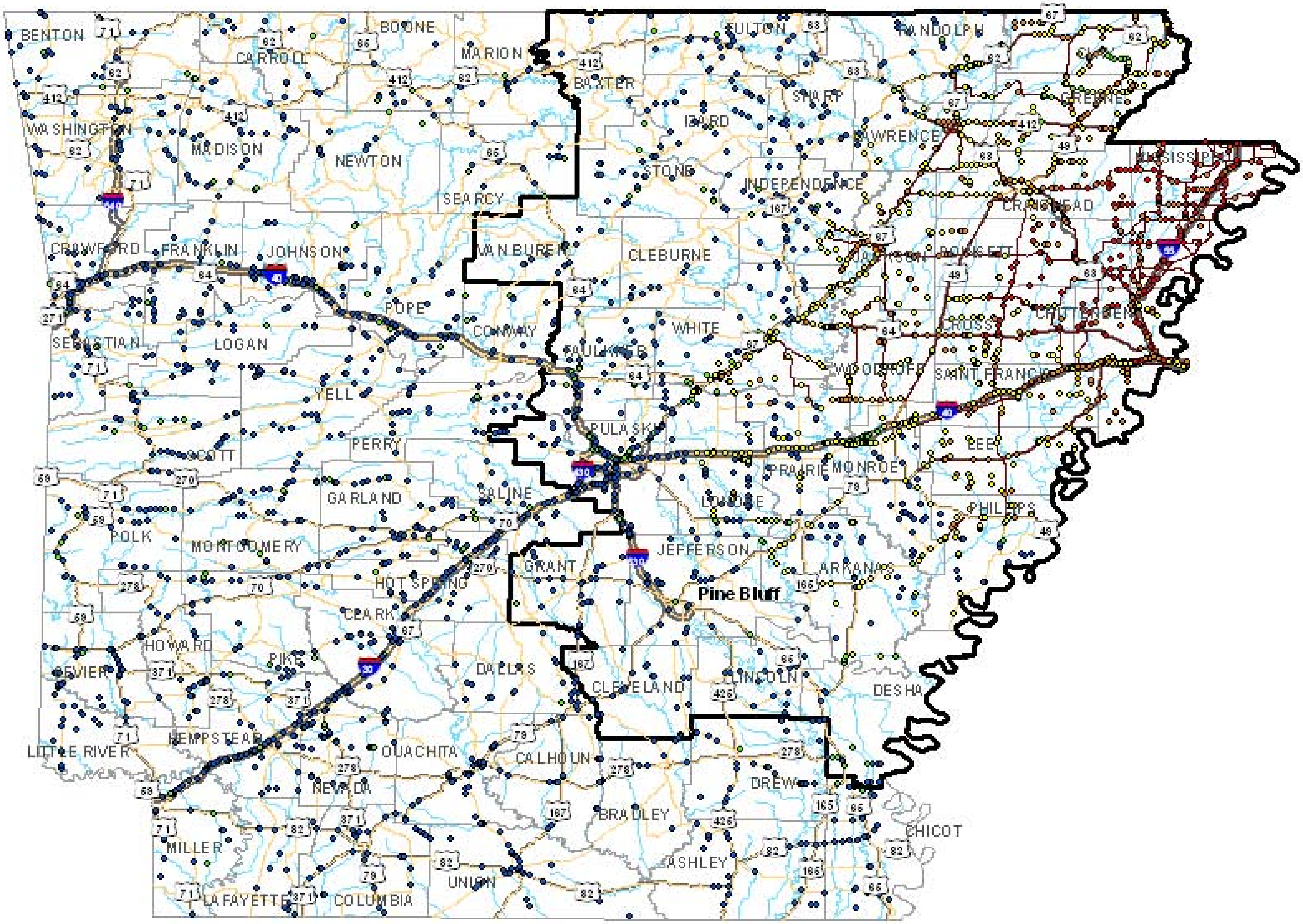
Highway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas
Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	61	0	0
Baxter	24	0	0
Clay	70	23	1
Cleburne	31	0	0
Cleveland	61	0	0
Craighead	124	77	30
Crittenden	147	113	50
Cross	83	41	23
Desha	37	0	0
Faulkner	90	0	0
Fulton	55	0	0
Grant	74	0	0
Greene	79	30	3
Independence	130	0	0
Izard	60	0	0
Jackson	71	33	0
Jefferson	92	0	0
Lawrence	68	13	0
Lee	43	11	0
Lincoln	40	0	0
Lonoke	117	1	0
Mississippi	147	147	119
Monroe	73	1	0
Phillips	45	4	0
Poinsett	95	85	61
Prairie	64	8	0
Pulaski	332	0	0
Randolph	67	4	0
Saint Francis	120	66	3
Sharp	63	0	0
Stone	40	0	0
Van Buren	48	0	0
White	181	12	0
Woodruff	51	19	0

Legend

Highway Bridge Damage

At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

US Routes
Interstate Highways
Critical Counties
Rivers

Highway Segment Damage

At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood

0 10 20 40 60
Miles

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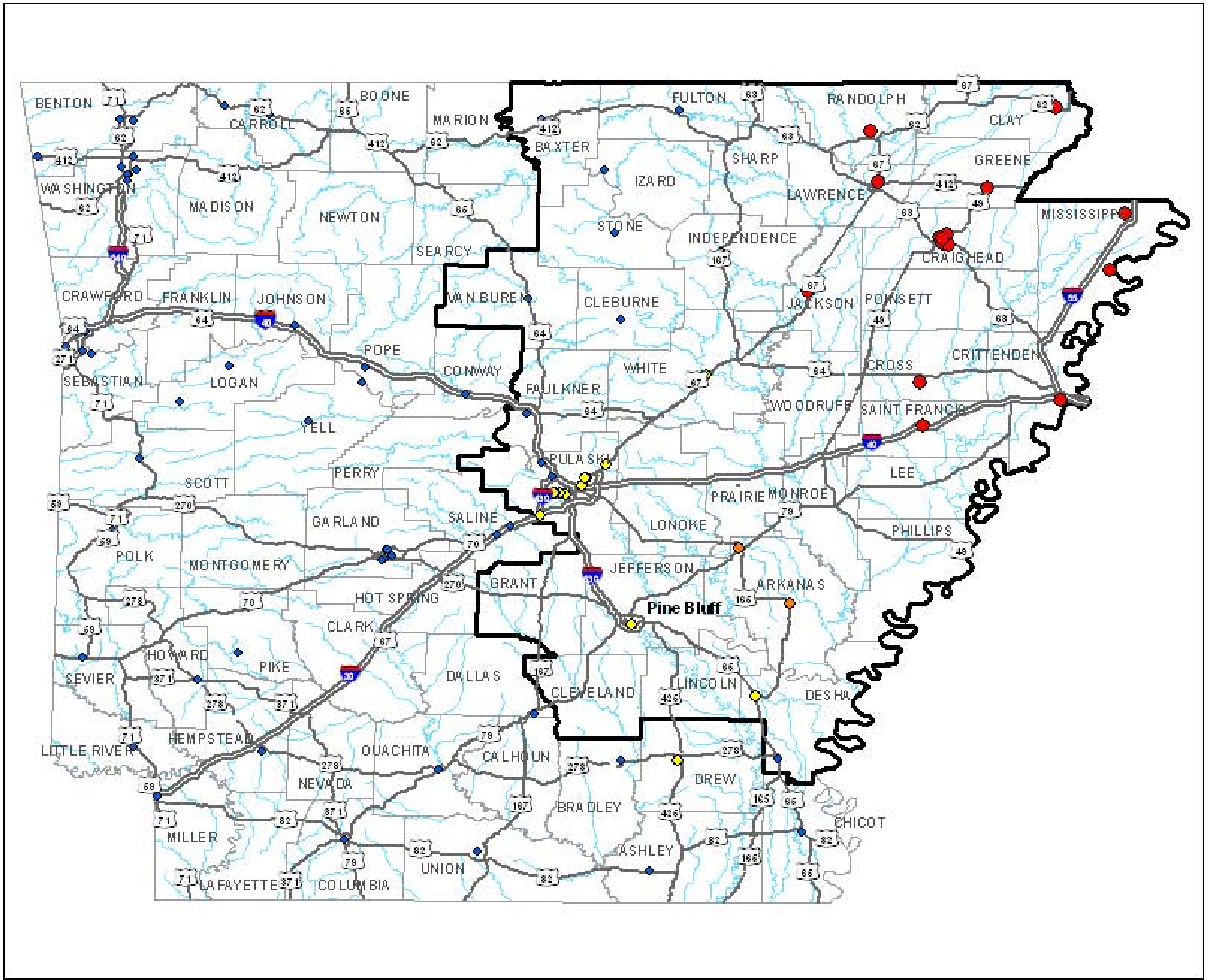
Hospital Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	2	2	0
Baxter	1	0	0
Clay	1	1	0
Cleburne	1	0	0
Cleveland	0	0	0
Craighead	5	5	5
Crittenden	1	1	1
Cross	1	1	1
Desha	2	0	0
Faulkner	1	0	0
Fulton	1	0	0
Grant	0	0	0
Greene	1	1	1
Independence	1	0	0
Izard	1	0	0
Jackson	1	1	0
Jefferson	1	0	0
Lawrence	1	1	0
Lee	0	0	0
Lincoln	0	0	0
Lonoke	0	0	0
Mississippi	2	2	2
Monroe	0	0	0
Phillips	1	1	0
Poinsett	0	0	0
Prairie	0	0	0
Pulaski	18	0	0
Randolph	1	1	0
Saint Francis	1	1	0
Sharp	0	0	0
Stone	1	0	0
Van Buren	1	0	0
White	2	0	0
Woodruff	0	0	0

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Critical Counties

Interstate Highways

US Routes

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

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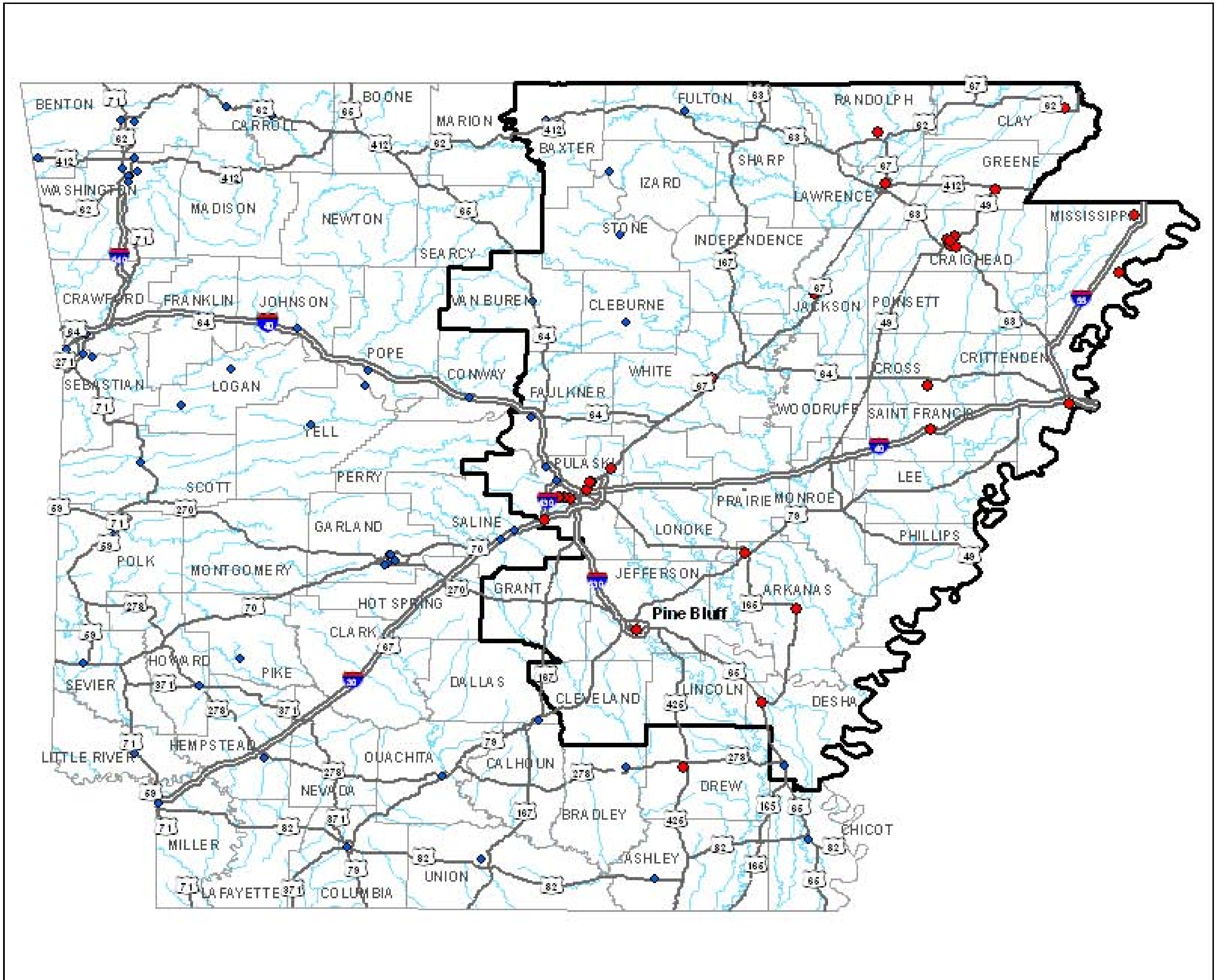
Hospital Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	0	2
Baxter	1	1
Clay	0	1
Cleburne	1	1
Cleveland	0	0
Craighead	0	5
Crittenden	0	1
Cross	0	1
Desha	1	2
Faulkner	1	1
Fulton	1	1
Grant	0	0
Greene	0	1
Independence	0	1
Izard	1	1
Jackson	0	1
Jefferson	0	1
Lawrence	0	1
Lee	0	0
Lincoln	0	0
Lonoke	0	0
Mississippi	0	2
Monroe	0	0
Phillips	0	1
Poinsett	0	0
Prairie	0	0
Pulaski	2	18
Randolph	0	1
Saint Francis	0	1
Sharp	0	0
Stone	1	1
Van Buren	1	1
White	0	2
Woodruff	0	0

Legend

Hospital Functionality

Day 1

- Not Functional
- Functional
- Interstate Highways
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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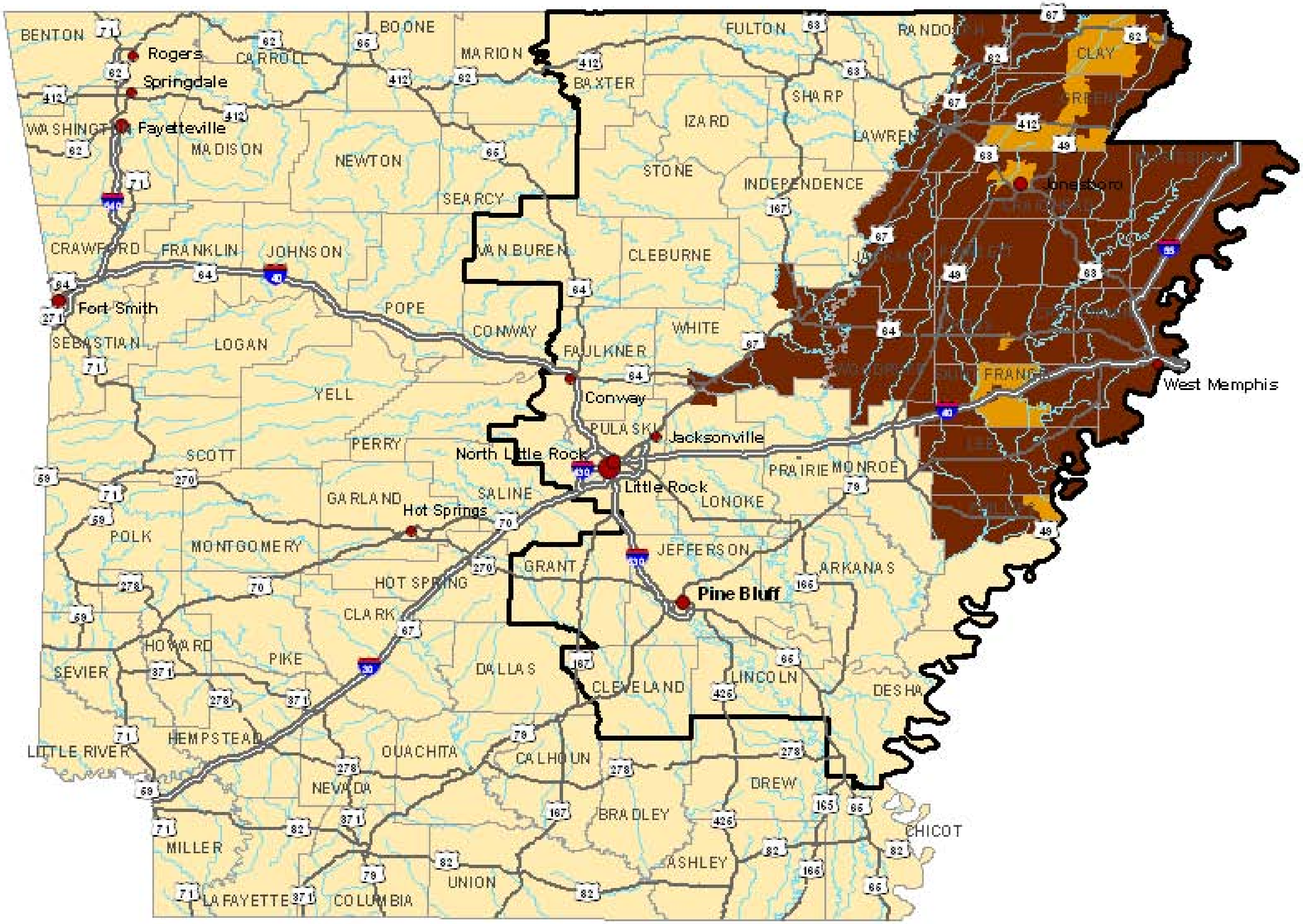
Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Minimum Susceptibility	Maximum Susceptibility
Arkansas	Unknown	Unknown
Baxter	Unknown	Unknown
Clay	Low	Very High
Cleburne	Unknown	None
Cleveland	Unknown	Unknown
Craighead	Low	Very High
Crittenden	Very High	Very High
Cross	Low	Very High
Desha	Unknown	Unknown
Faulkner	Unknown	Unknown
Fulton	Unknown	None
Grant	Unknown	Unknown
Greene	Low	Very High
Independence	None	None
Izard	Unknown	None
Jackson	None	Very High
Jefferson	Unknown	Unknown
Lawrence	None	Very High
Lee	Unknown	Very High
Lincoln	Unknown	Unknown
Lonoke	Unknown	Very High
Mississippi	Very High	Very High
Monroe	Unknown	None
Phillips	Unknown	Very High
Poinsett	Very High	Very High
Prairie	Unknown	None
Pulaski	Unknown	Unknown
Randolph	None	Very High
Saint Francis	Unknown	Very High
Sharp	None	None
Stone	Unknown	None
Van Buren	Unknown	Unknown
White	Unknown	Very High
Woodruff	Unknown	Very High

Legend

Liquefaction Susceptibility

- None
- Low
- Very High

Major Cities

Population in 2000

- 28,000 - 40,000
- 40,001 - 75,000
- 75,001 - 180,000

- US Routes
- Interstate Highways
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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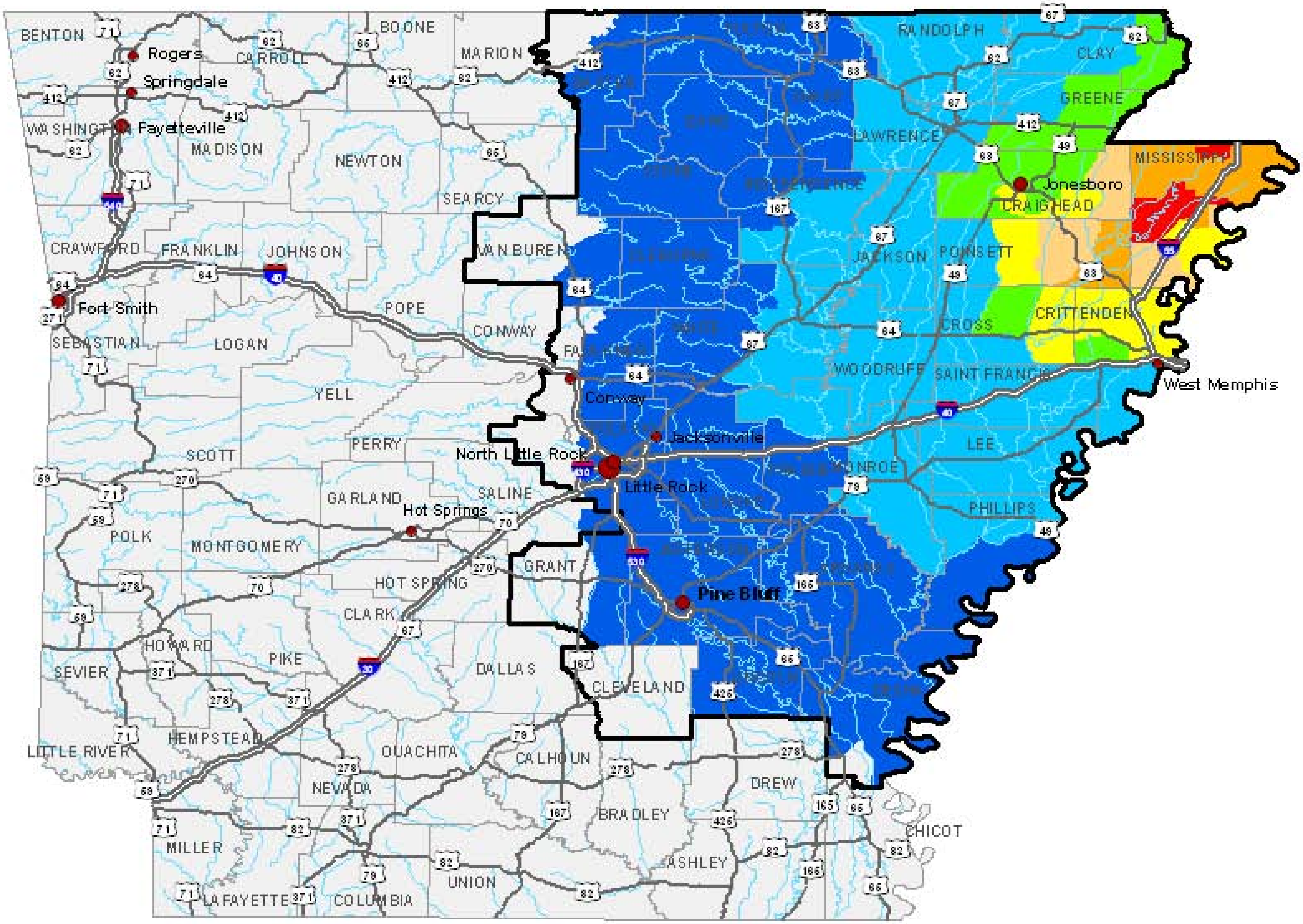
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Max. MMI
Arkansas	VI
Baxter	VI
Clay	VIII
Cleburne	VI
Cleveland	< VI
Craighead	X
Crittenden	IX
Cross	IX
Desha	VI
Faulkner	VI
Fulton	VI
Grant	VI
Greene	VIII
Independence	VII
Izard	VI
Jackson	VII
Jefferson	VI
Lawrence	VII
Lee	VII
Lincoln	VI
Lonoke	VI
Mississippi	XII
Monroe	VII
Phillips	VII
Poinsett	XI
Prairie	VII
Pulaski	VI
Randolph	VII
Saint Francis	VII
Sharp	VI
Stone	VI
Van Buren	VI
White	VII
Woodruff	VII

Legend

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities Population in 2000

- 28,000 - 40,000
- 40,001 - 75,000
- 75,001 - 180,000

- US Routes
- Interstate Highways
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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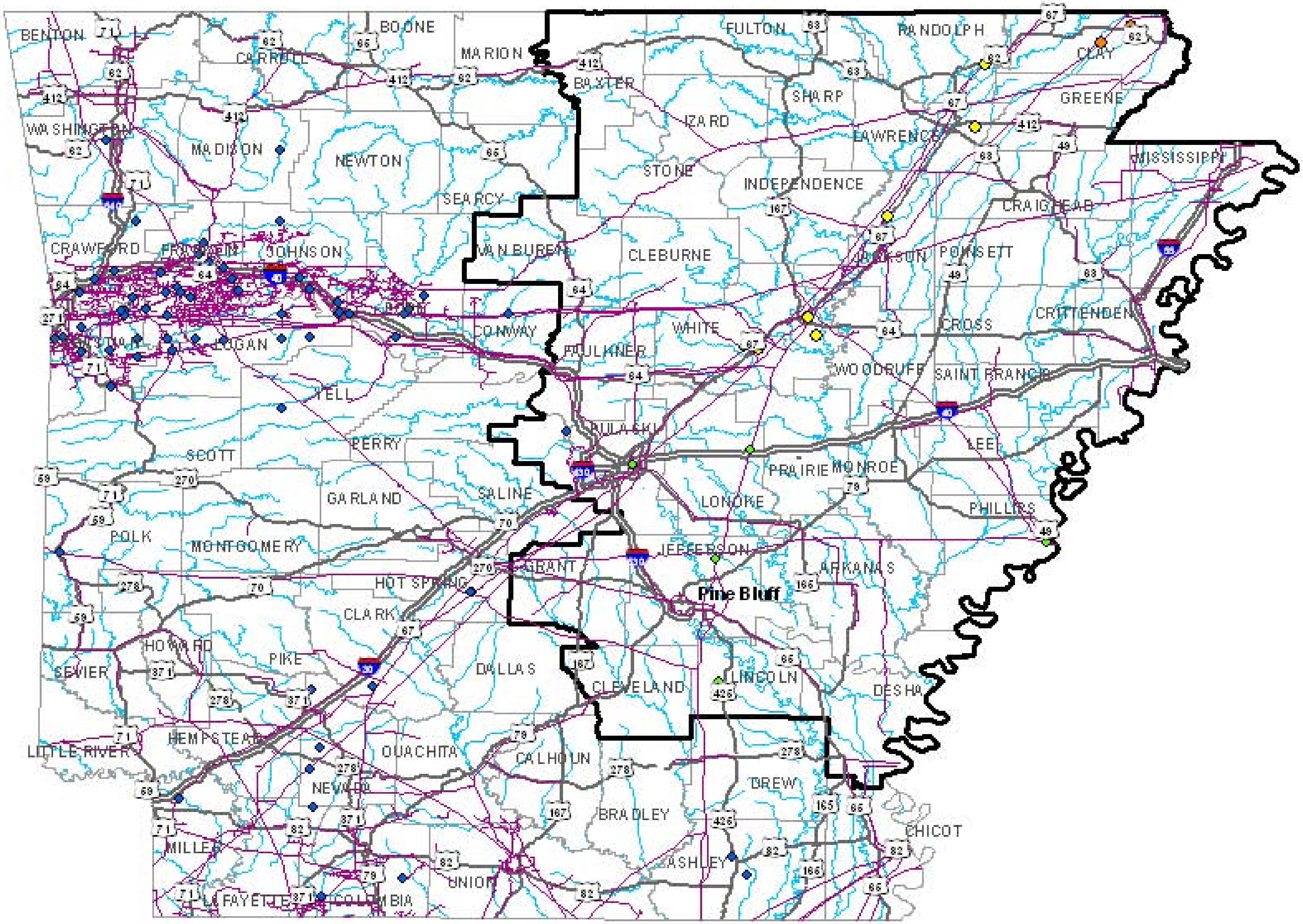
Natural Gas Facilities Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	0	0	0
Baxter	0	0	0
Clay	2	2	0
Cleburne	0	0	0
Cleveland	0	0	0
Craighead	0	0	0
Crittenden	0	0	0
Cross	0	0	0
Desha	0	0	0
Faulkner	1	0	0
Fulton	0	0	0
Grant	0	0	0
Greene	0	0	0
Independence	0	0	0
Izard	0	0	0
Jackson	2	0	0
Jefferson	1	0	0
Lawrence	1	0	0
Lee	0	0	0
Lincoln	1	0	0
Lonoke	1	0	0
Mississippi	0	0	0
Monroe	0	0	0
Phillips	1	0	0
Poinsett	0	0	0
Prairie	0	0	0
Pulaski	1	0	0
Randolph	3	0	0
Saint Francis	0	0	0
Sharp	0	0	0
Stone	0	0	0
Van Buren	0	0	0
White	4	0	0
Woodruff	0	0	0

Legend

Natural Gas Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely
- Major Gas Transmission Lines
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

0 10 20 40 60

Miles

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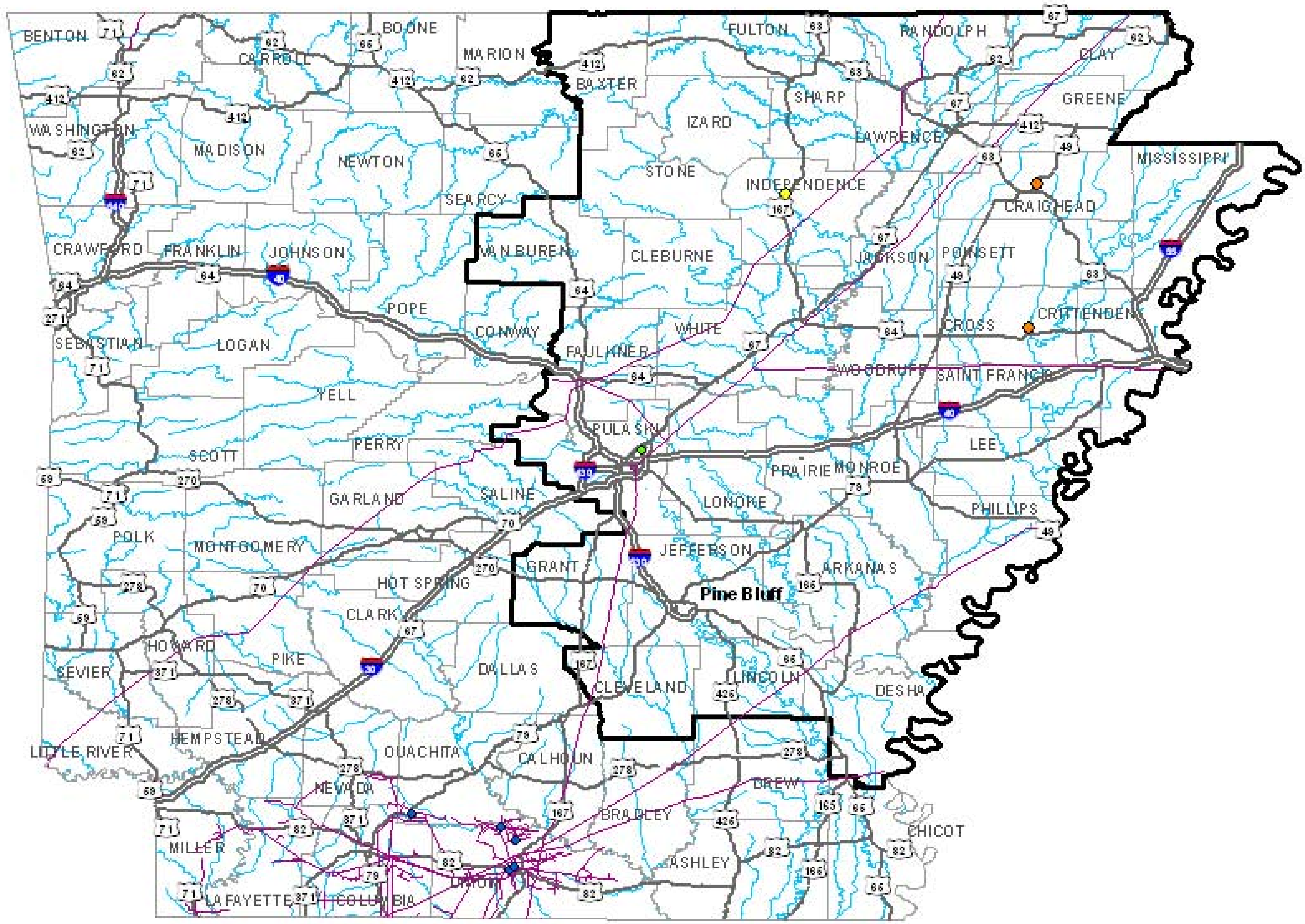
Oil Facilities Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	0	0	0
Baxter	0	0	0
Clay	0	0	0
Cleburne	0	0	0
Cleveland	0	0	0
Craighead	1	1	0
Crittenden	0	0	0
Cross	1	1	0
Desha	0	0	0
Faulkner	0	0	0
Fulton	0	0	0
Grant	0	0	0
Greene	0	0	0
Independence	1	0	0
Izard	0	0	0
Jackson	1	0	0
Jefferson	0	0	0
Lawrence	0	0	0
Lee	0	0	0
Lincoln	0	0	0
Lonoke	0	0	0
Mississippi	0	0	0
Monroe	0	0	0
Phillips	0	0	0
Poinsett	0	0	0
Prairie	0	0	0
Pulaski	1	0	0
Randolph	0	0	0
Saint Francis	0	0	0
Sharp	0	0	0
Stone	0	0	0
Van Buren	0	0	0
White	0	0	0
Woodruff	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely
- Oil Pipelines
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

0 10 20 40 60

Miles

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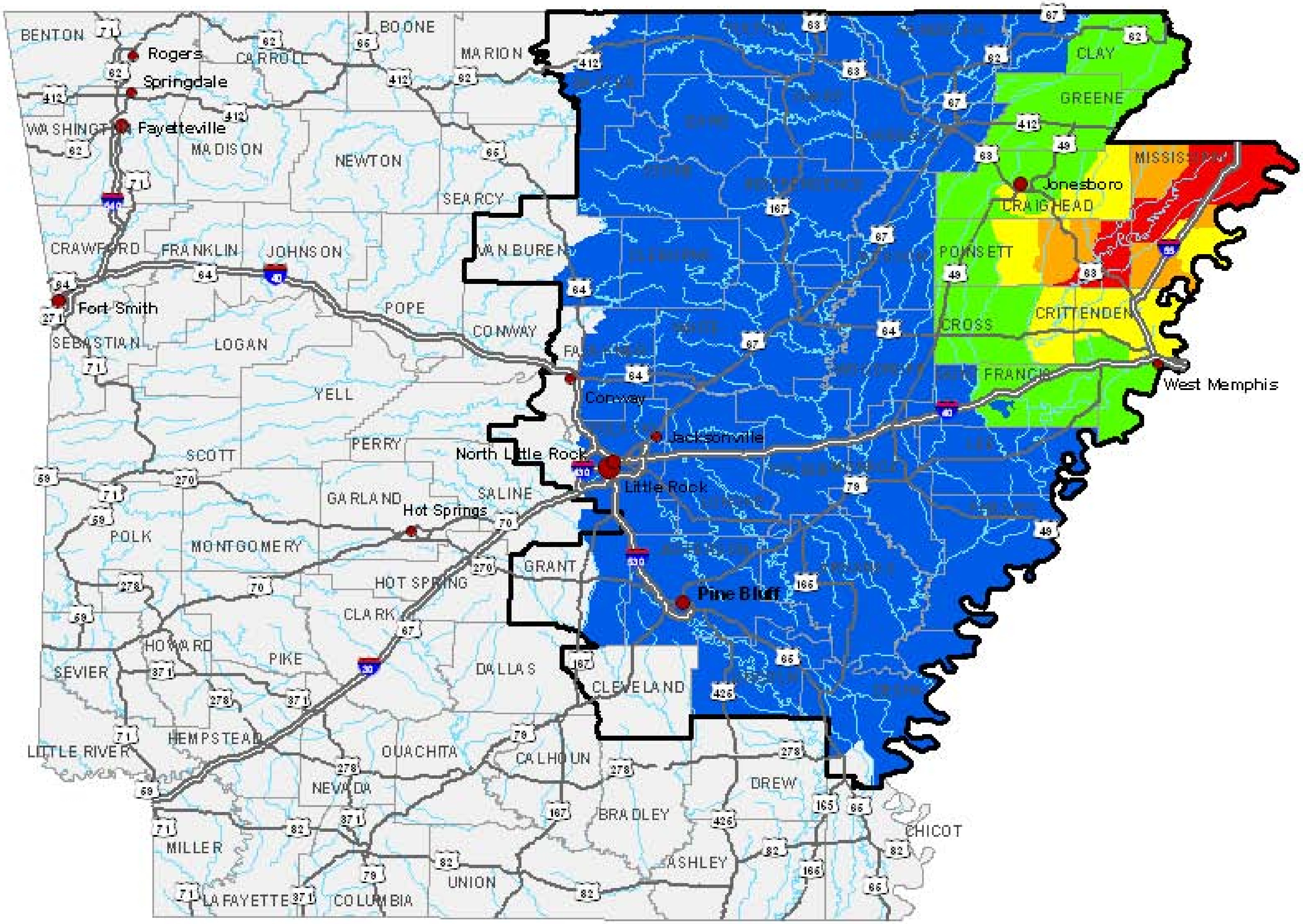
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Min. PGA	Max. PGA
Arkansas	0.15	0.15
Baxter	0.05	0.15
Clay	0.25	0.44
Cleburne	0.15	0.15
Cleveland	0.07	0.07
Craighead	0.44	0.75
Crittenden	0.34	0.64
Cross	0.34	0.55
Desha	0.05	0.15
Faulkner	0.05	0.15
Fulton	0.15	0.15
Grant	0.05	0.15
Greene	0.34	0.44
Independence	0.15	0.25
Izard	0.15	0.15
Jackson	0.25	0.25
Jefferson	0.15	0.15
Lawrence	0.25	0.25
Lee	0.25	0.25
Lincoln	0.15	0.15
Lonoke	0.15	0.15
Mississippi	0.64	1.23
Monroe	0.25	0.25
Phillips	0.15	0.25
Poinsett	0.34	1.14
Prairie	0.15	0.25
Pulaski	0.05	0.15
Randolph	0.25	0.25
Saint Francis	0.25	0.34
Sharp	0.15	0.15
Stone	0.15	0.15
Van Buren	0.05	0.15
White	0.15	0.25
Woodruff	0.25	0.25

Legend

PGA (g)

- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.23
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

Major Cities
Population in 2000

- 28,000 - 40,000
- 40,001 - 75,000
- 75,001 - 180,000

0 10 20 40 60
Miles

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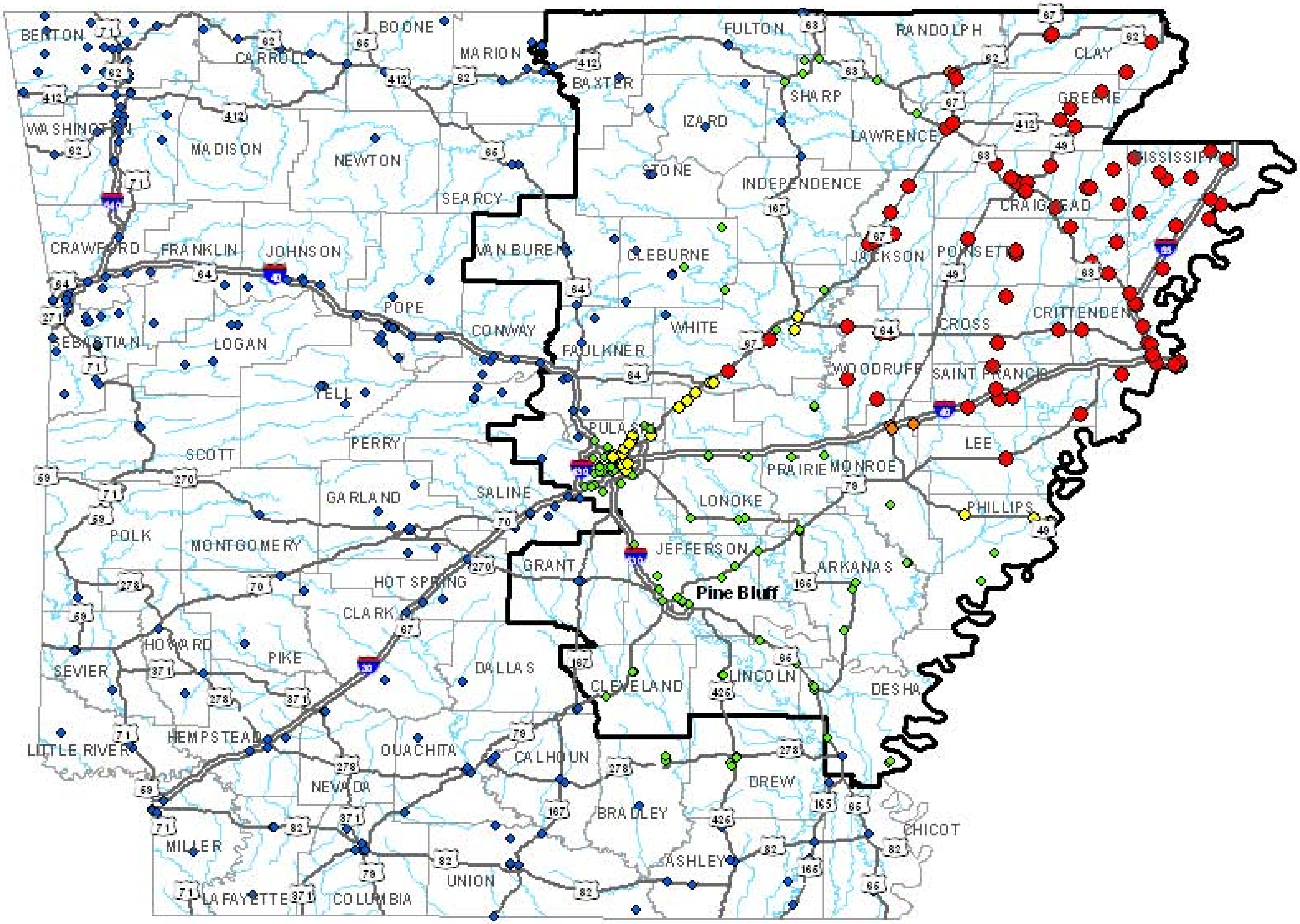
Police Station Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	8	0	0
Baxter	6	0	0
Clay	5	5	1
Cleburne	6	0	0
Cleveland	3	0	0
Craighead	13	13	11
Crittenden	14	14	10
Cross	4	4	2
Desha	10	0	0
Faulkner	10	0	0
Fulton	4	0	0
Grant	2	0	0
Greene	4	4	1
Independence	2	0	0
Izard	3	0	0
Jackson	8	8	0
Jefferson	12	0	0
Lawrence	5	3	0
Lee	2	2	0
Lincoln	4	0	0
Lonoke	9	0	0
Mississippi	12	12	12
Monroe	6	2	0
Phillips	6	1	0
Poinsett	7	7	6
Prairie	4	0	0
Pulaski	57	0	0
Randolph	3	3	0
Saint Francis	8	8	0
Sharp	7	0	0
Stone	2	0	0
Van Buren	3	0	0
White	12	2	0
Woodruff	6	6	0

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Critical Counties

Interstate Highways

US Routes

Rivers

0 10 20 40 60

Miles

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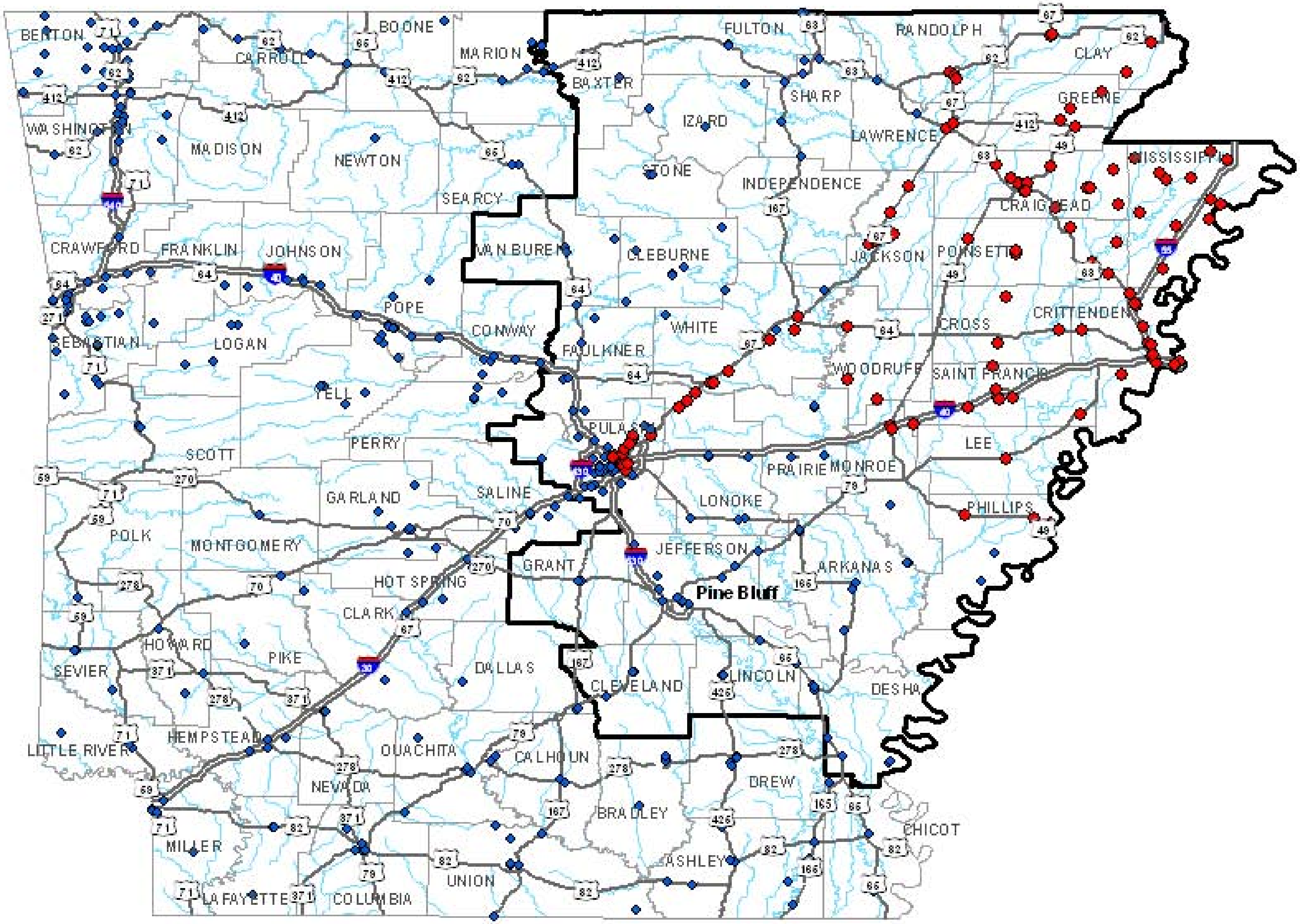
Police Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	8	8
Baxter	6	6
Clay	0	5
Cleburne	6	6
Cleveland	3	3
Craighead	0	13
Crittenden	0	14
Cross	0	4
Desha	10	10
Faulkner	10	10
Fulton	4	4
Grant	2	2
Greene	0	4
Independence	2	2
Izard	3	3
Jackson	0	8
Jefferson	12	12
Lawrence	2	5
Lee	0	2
Lincoln	4	4
Lonoke	6	9
Mississippi	0	12
Monroe	4	6
Phillips	2	6
Poinsett	0	7
Prairie	4	4
Pulaski	44	57
Randolph	0	3
Saint Francis	0	8
Sharp	7	7
Stone	2	2
Van Buren	3	3
White	6	12
Woodruff	0	6

Legend

Police Station Functionality

Day 1

- Not Functional
- Functional
- Interstate Highways
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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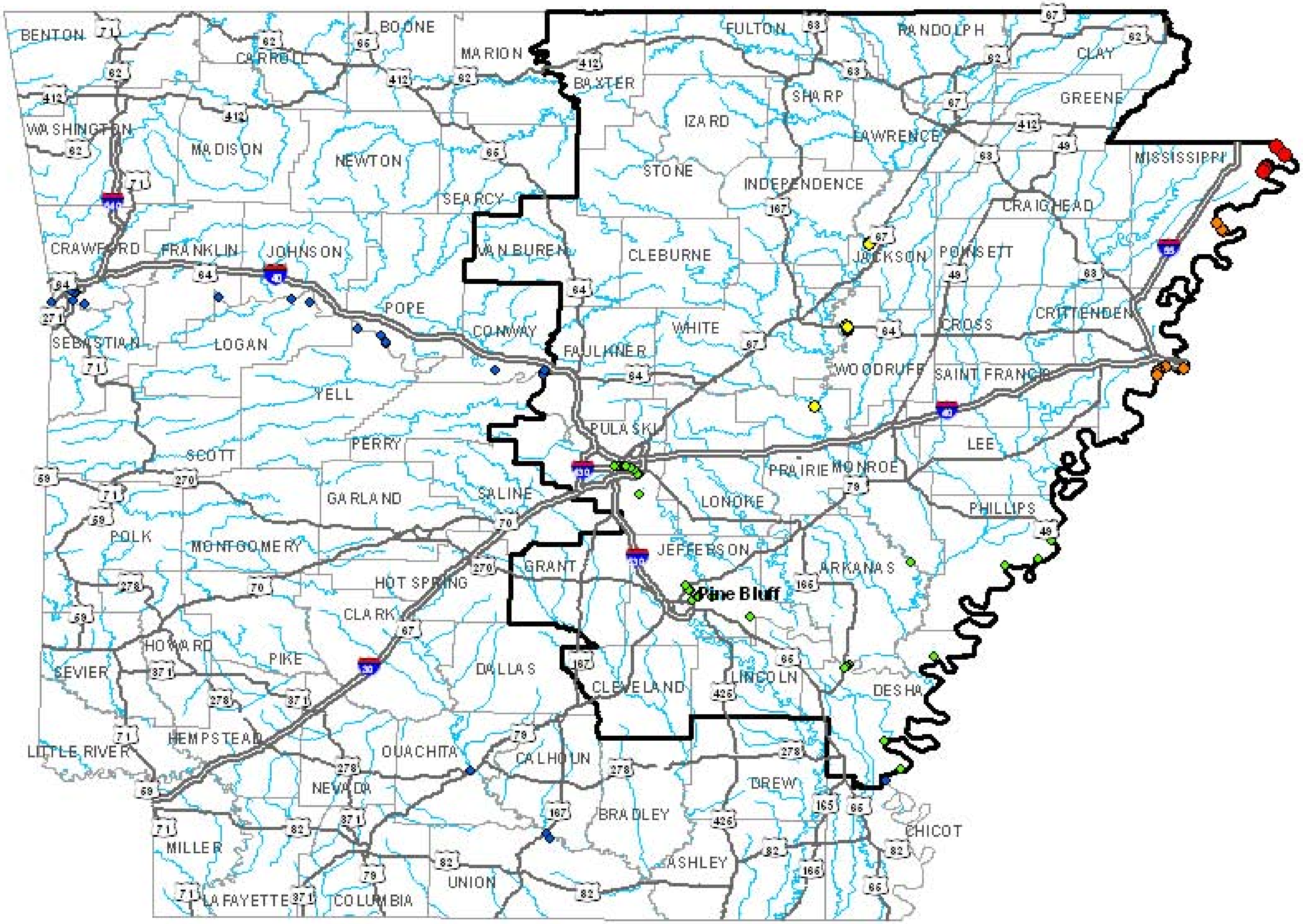
Port Facilities Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	1	0	0
Baxter	0	0	0
Clay	0	0	0
Cleburne	0	0	0
Cleveland	0	0	0
Craighead	0	0	0
Crittenden	6	6	0
Cross	0	0	0
Desha	7	0	0
Faulkner	1	0	0
Fulton	0	0	0
Grant	0	0	0
Greene	0	0	0
Independence	0	0	0
Izard	0	0	0
Jackson	2	0	0
Jefferson	13	0	0
Lawrence	0	0	0
Lee	0	0	0
Lincoln	0	0	0
Lonoke	0	0	0
Mississippi	11	11	7
Monroe	4	0	0
Phillips	14	0	0
Poinsett	0	0	0
Prairie	1	0	0
Pulaski	13	0	0
Randolph	0	0	0
Saint Francis	0	0	0
Sharp	0	0	0
Stone	0	0	0
Van Buren	0	0	0
White	0	0	0
Woodruff	5	0	0

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Critical Counties

Interstate Highways

US Routes

Rivers

0 10 20 40 60

Miles

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Theresa Jefferson, Principal Investigator

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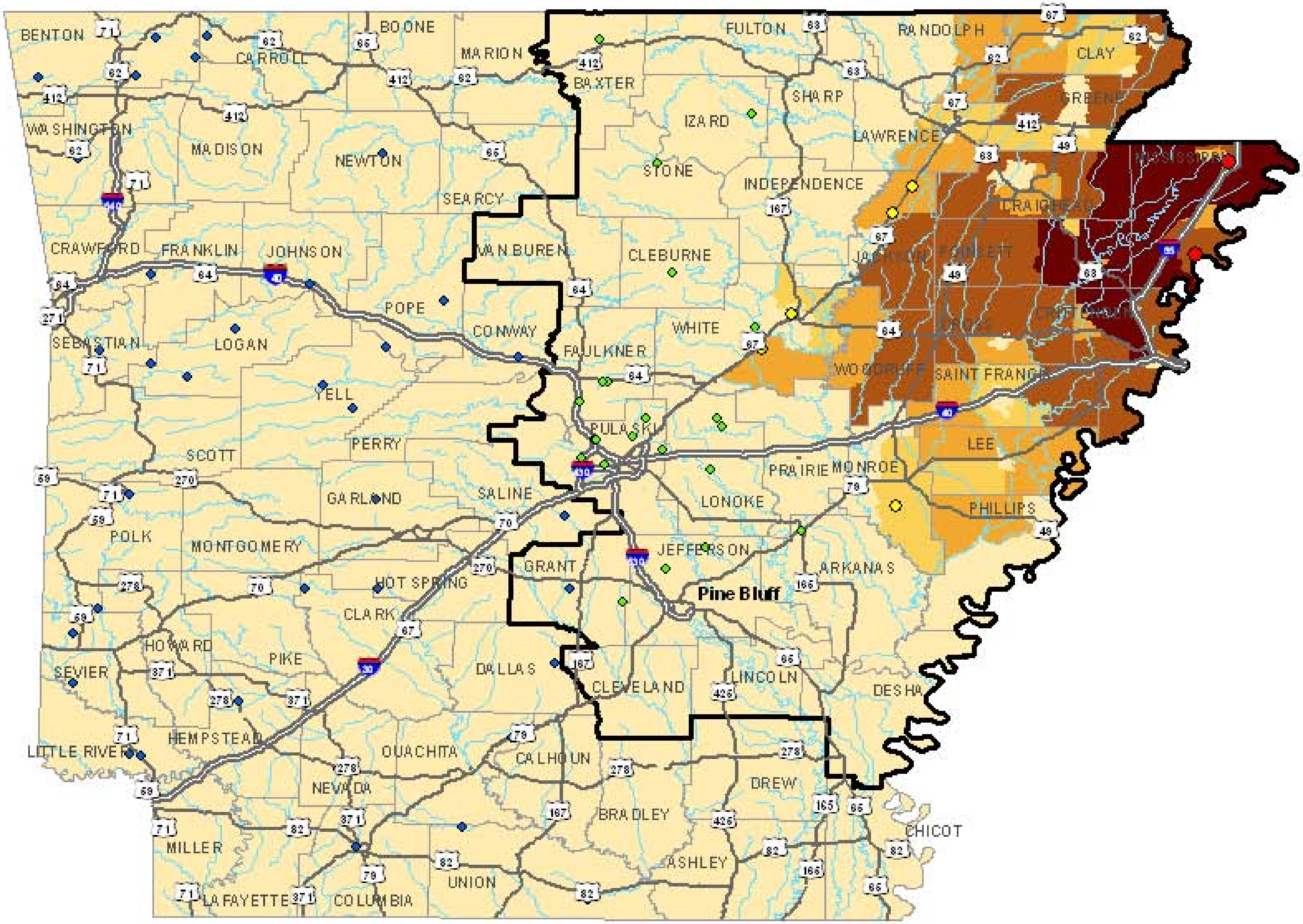
Potable Water Facilities Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	1	0	0
Baxter	1	0	0
Clay	0	0	0
Cleburne	1	0	0
Cleveland	0	0	0
Craighead	0	0	0
Crittenden	0	0	0
Cross	0	0	0
Desha	0	0	0
Faulkner	3	0	0
Fulton	0	0	0
Grant	2	0	0
Greene	0	0	0
Independence	1	0	0
Izard	1	0	0
Jackson	2	0	0
Jefferson	2	0	0
Lawrence	0	0	0
Lee	0	0	0
Lincoln	0	0	0
Lonoke	3	0	0
Mississippi	2	2	1
Monroe	1	0	0
Phillips	0	0	0
Poinsett	0	0	0
Prairie	0	0	0
Pulaski	7	0	0
Randolph	0	0	0
Saint Francis	0	0	0
Sharp	0	0	0
Stone	1	0	0
Van Buren	0	0	0
White	3	0	0
Woodruff	0	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Potable Water Distribution Lines

No. of Leaks

- 0 - 50
- 51 - 100
- 101 - 200
- 201 - 500
- 501 - 1,550

- Critical Counties
- Interstate Highways
- US Routes
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

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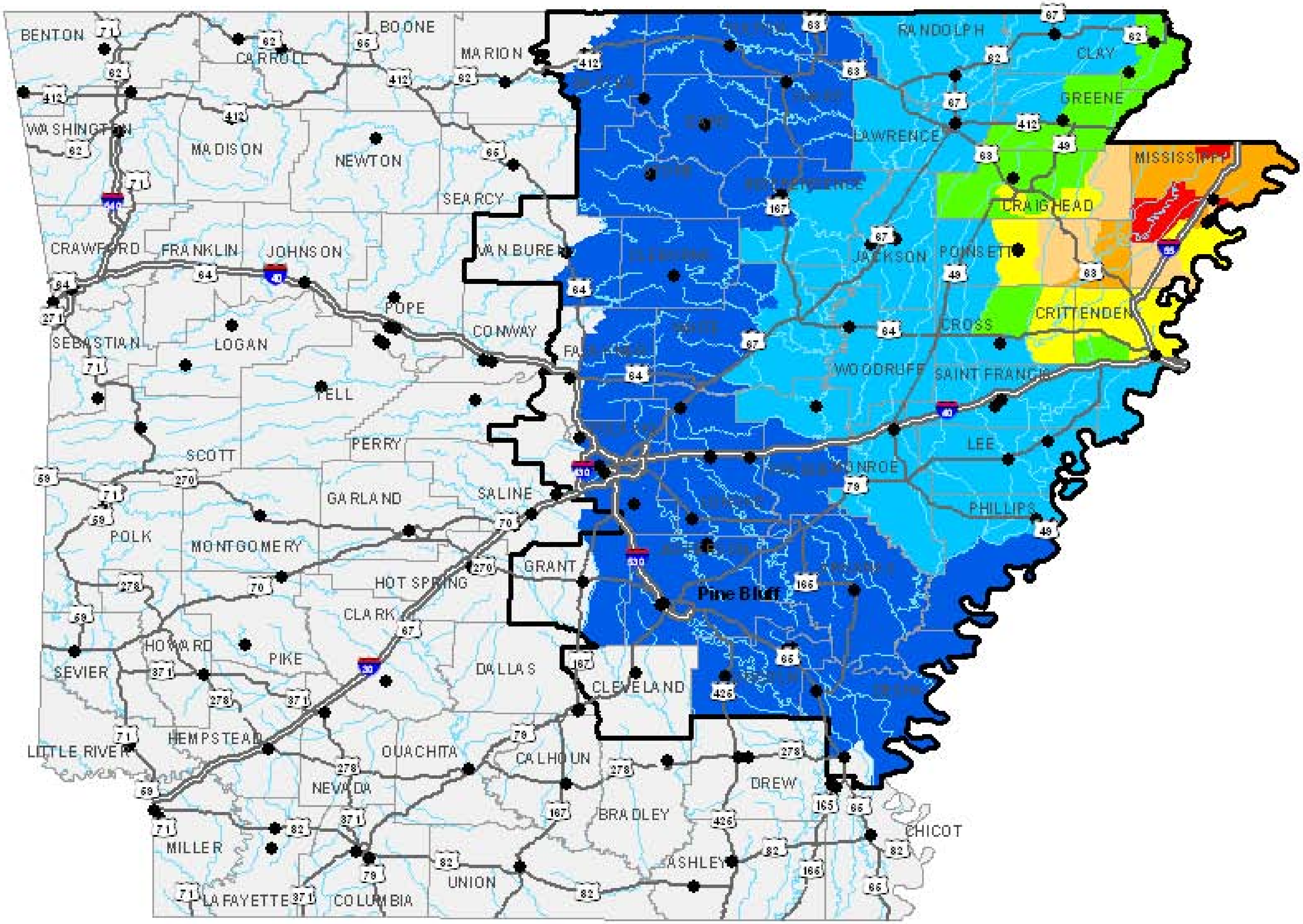
Prisons - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Facilities
Arkansas	1
Baxter	1
Clay	3
Cleburne	1
Cleveland	1
Craighead	1
Crittenden	1
Cross	1
Desha	2
Faulkner	1
Fulton	1
Grant	1
Greene	1
Independence	2
Izard	2
Jackson	3
Jefferson	6
Lawrence	1
Lee	2
Lincoln	3
Lonoke	5
Mississippi	4
Monroe	2
Phillips	2
Poinsett	2
Prairie	1
Pulaski	4
Randolph	1
Saint Francis	2
Sharp	1
Stone	1
Van Buren	1
White	1
Woodruff	1

Legend

- Prisons
- Critical Counties
- Interstate Highways
- US Routes
- Rivers

MMI

- <VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

0 10 20 40 60

Miles

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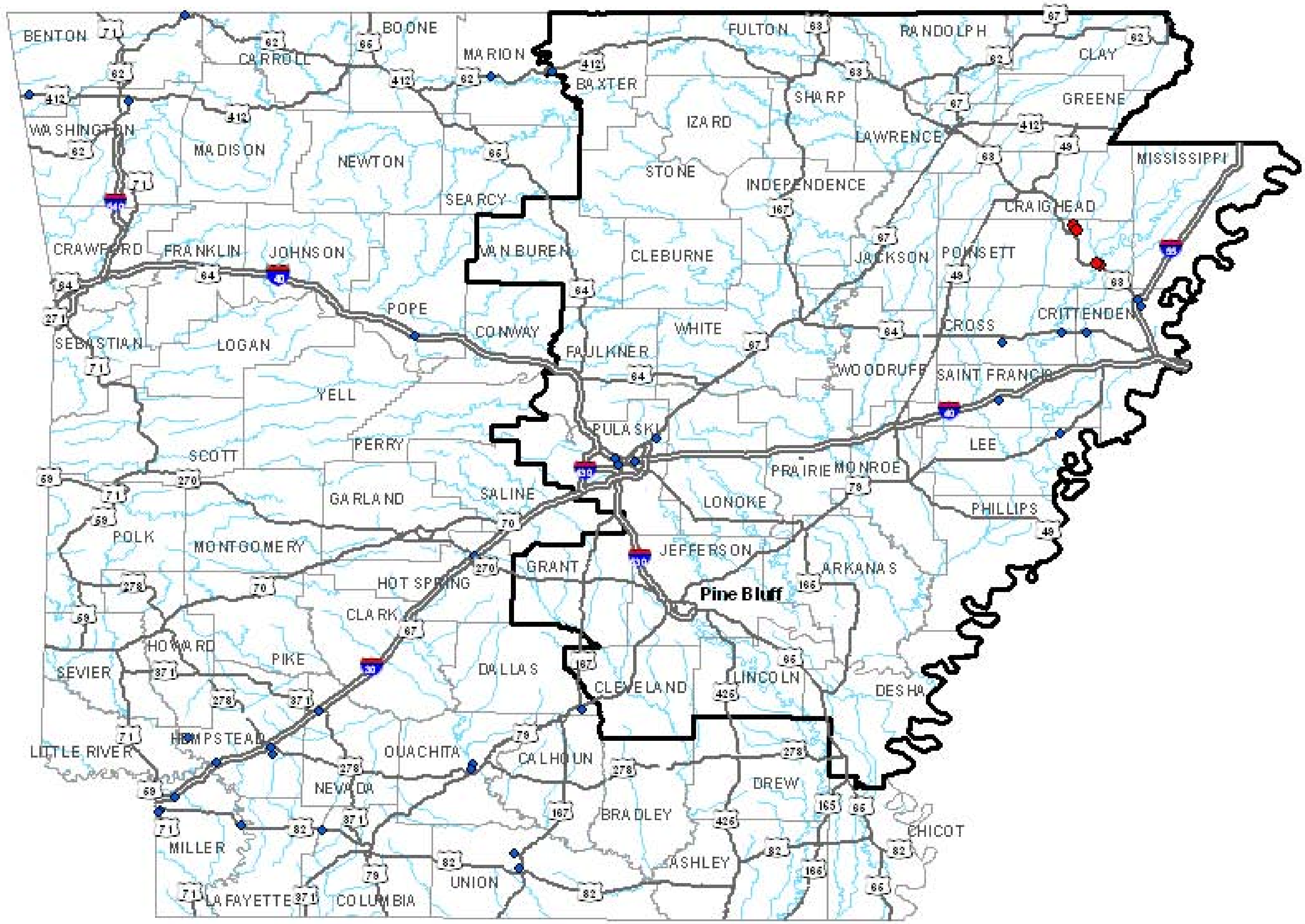
Railway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas
Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	0	0
Baxter	1	1
Clay	0	0
Cleburne	0	0
Cleveland	0	0
Craighead	0	0
Crittenden	6	6
Cross	3	3
Desha	0	0
Faulkner	0	0
Fulton	0	0
Grant	0	0
Greene	0	0
Independence	0	0
Izard	0	0
Jackson	0	0
Jefferson	0	0
Lawrence	0	0
Lee	1	1
Lincoln	0	0
Lonoke	0	0
Mississippi	0	0
Monroe	0	0
Phillips	0	0
Poinsett	0	4
Prairie	0	0
Pulaski	4	4
Randolph	0	0
Saint Francis	1	1
Sharp	0	0
Stone	0	0
Van Buren	0	0
White	0	0
Woodruff	0	0

Legend

Railway Bridge Functionality

Day 1

- Not Functional
- Functional
- Interstate Highways
- US Routes
- Rivers
- Critical Counties

0 10 20 40 60

Miles

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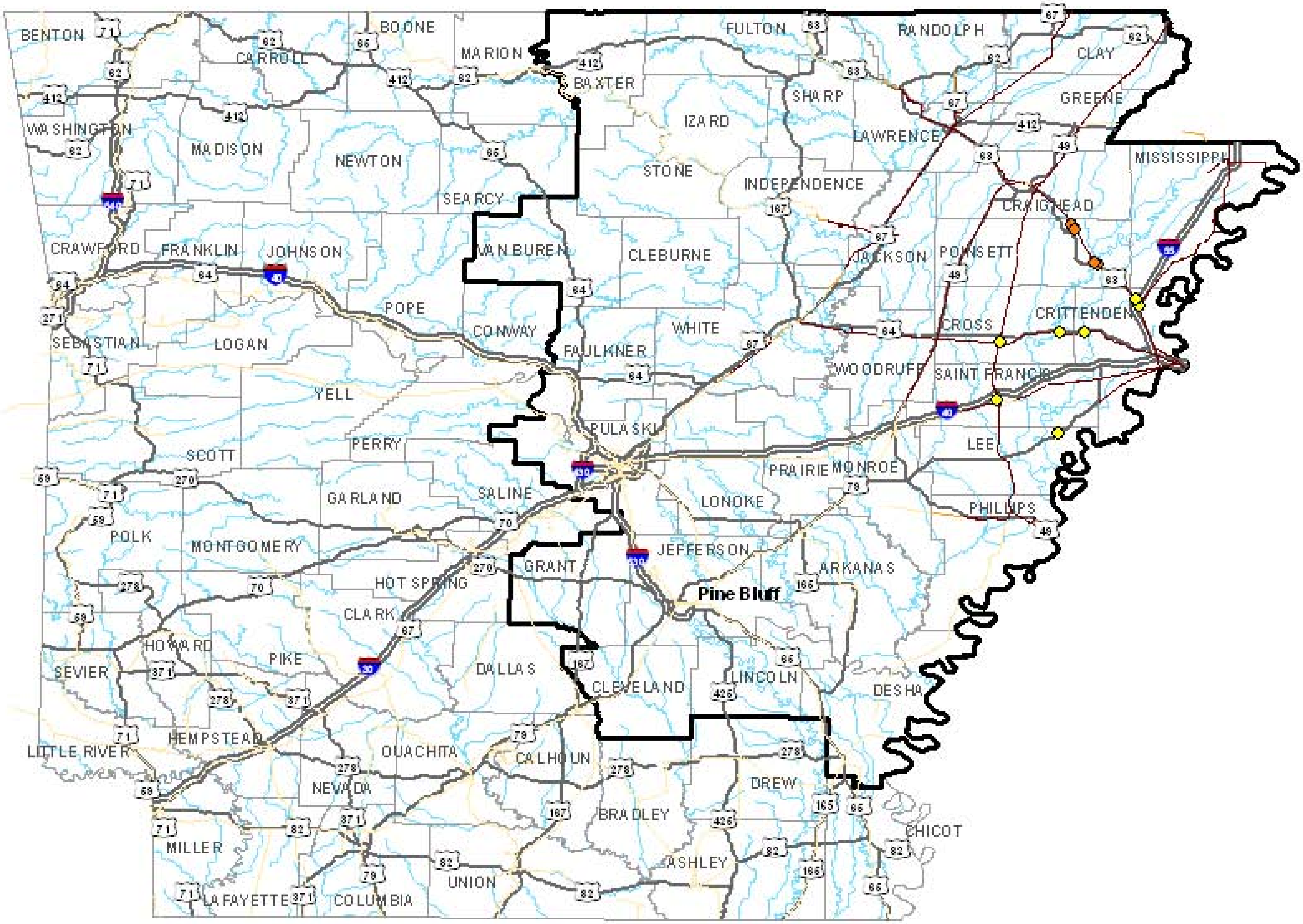
Railway Bridge Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	0	0	0
Baxter	1	0	0
Clay	0	0	0
Cleburne	0	0	0
Cleveland	0	0	0
Craighead	0	0	0
Crittenden	6	0	0
Cross	3	0	0
Desha	0	0	0
Faulkner	0	0	0
Fulton	0	0	0
Grant	0	0	0
Greene	0	0	0
Independence	0	0	0
Izard	0	0	0
Jackson	0	0	0
Jefferson	0	0	0
Lawrence	0	0	0
Lee	1	0	0
Lincoln	0	0	0
Lonoke	0	0	0
Mississippi	0	0	0
Monroe	0	0	0
Phillips	0	0	0
Poinsett	4	4	0
Prairie	0	0	0
Pulaski	4	0	0
Randolph	0	0	0
Saint Francis	1	0	0
Sharp	0	0	0
Stone	0	0	0
Van Buren	0	0	0
White	0	0	0
Woodruff	0	0	0

Legend

Railway Bridge Damage

At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Railway Segment Damage

At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood

Rivers
US Routes
Interstate Highways
Critical Counties

0 10 20 40 60
Miles

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Mid-America Earthquake Center

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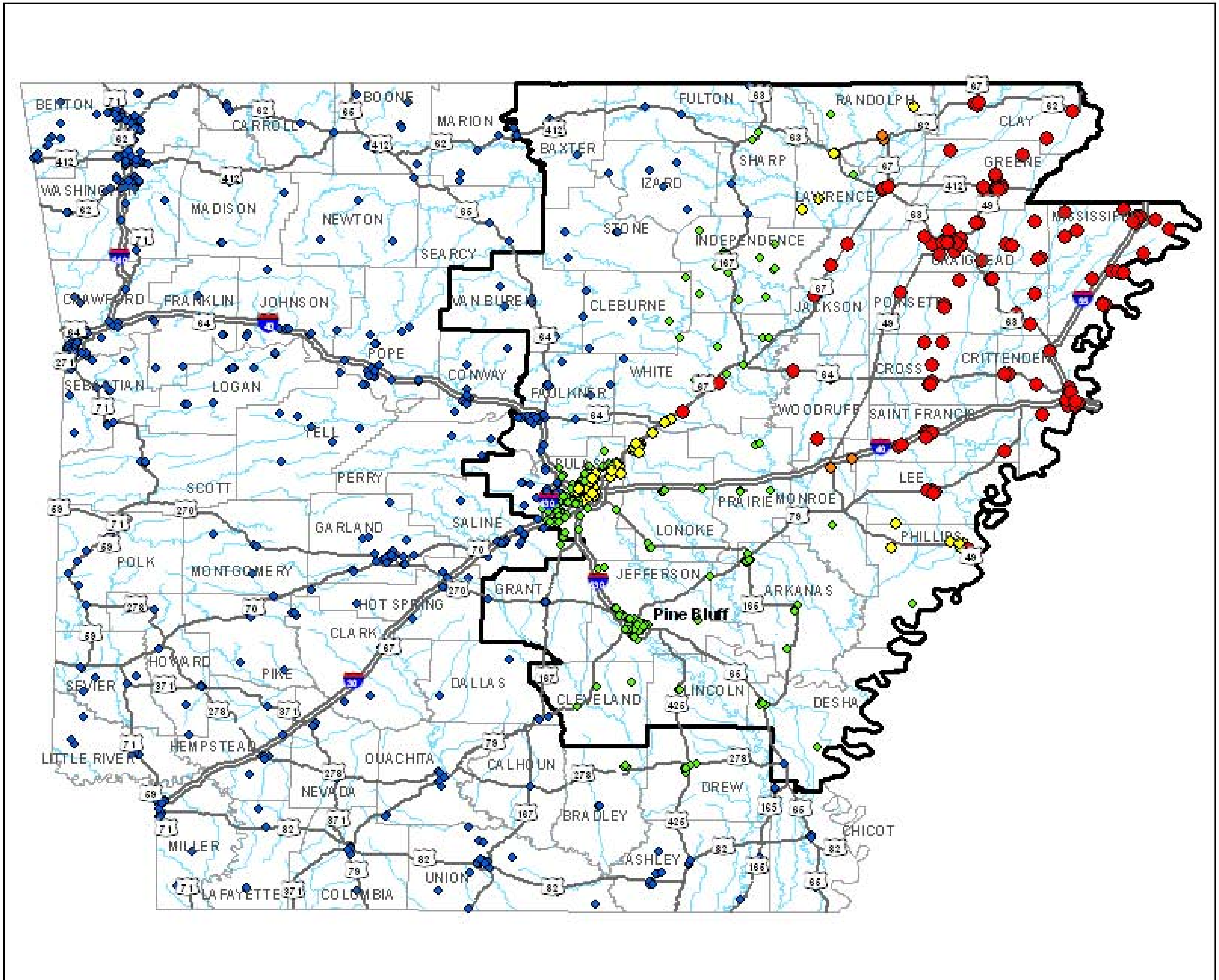
Theresa Jefferson, Principal Investigator

School Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	13	0	0
Baxter	10	0	0
Clay	7	7	2
Cleburne	12	0	0
Cleveland	5	0	0
Craighead	39	39	36
Crittenden	27	27	11
Cross	7	7	3
Desha	10	0	0
Faulkner	38	0	0
Fulton	5	0	0
Grant	6	0	0
Greene	17	17	12
Independence	20	0	0
Izard	9	0	0
Jackson	7	7	0
Jefferson	40	0	0
Lawrence	14	5	0
Lee	7	6	0
Lincoln	3	0	0
Lonoke	22	0	0
Mississippi	30	30	30
Monroe	5	2	0
Phillips	15	1	0
Poinsett	14	14	12
Prairie	5	0	0
Pulaski	142	0	0
Randolph	10	5	0
Saint Francis	13	13	0
Sharp	8	0	0
Stone	6	0	0
Van Buren	8	0	0
White	34	3	0
Woodruff	5	5	0

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Rivers

Critical Counties

Interstate Highways

US Routes

0 10 20 40 60

Miles

Mid-America Earthquake Center

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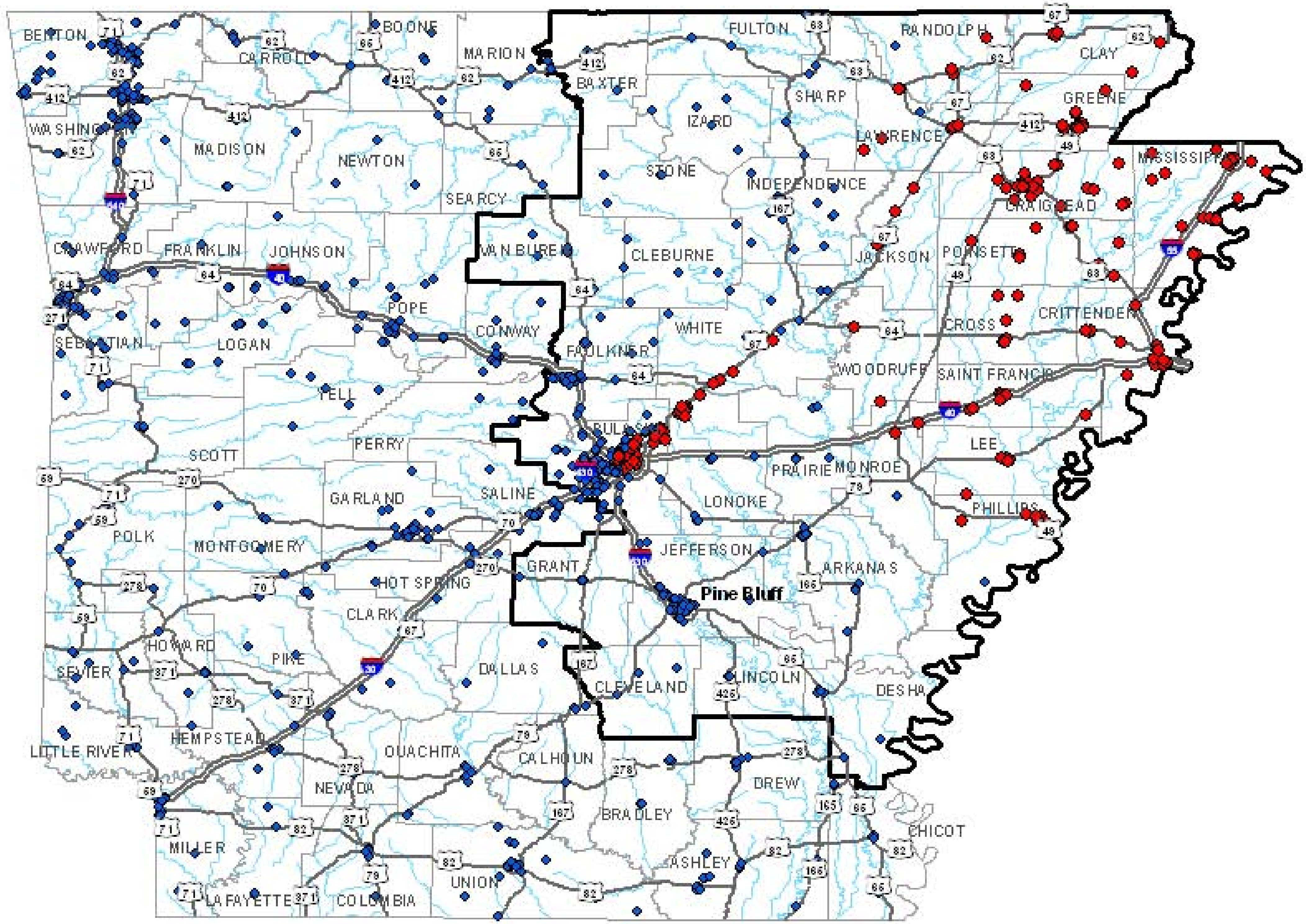
School Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	No. of Functional Facilities	Total No. of Facilities
Arkansas	13	13
Baxter	10	10
Clay	0	7
Cleburne	12	12
Cleveland	5	5
Craighead	0	39
Crittenden	0	27
Cross	0	7
Desha	10	10
Faulkner	38	38
Fulton	5	5
Grant	6	6
Greene	0	17
Independence	20	20
Izard	9	9
Jackson	0	7
Jefferson	40	40
Lawrence	2	14
Lee	0	7
Lincoln	3	3
Lonoke	9	22
Mississippi	0	30
Monroe	3	5
Phillips	4	15
Poinsett	0	14
Prairie	5	5
Pulaski	111	142
Randolph	1	10
Saint Francis	0	13
Sharp	8	8
Stone	6	6
Van Buren	8	8
White	25	34
Woodruff	0	5

Legend

School Functionality

Day 1

- Not Functional
- Functional
- Interstate Highways
- US Routes
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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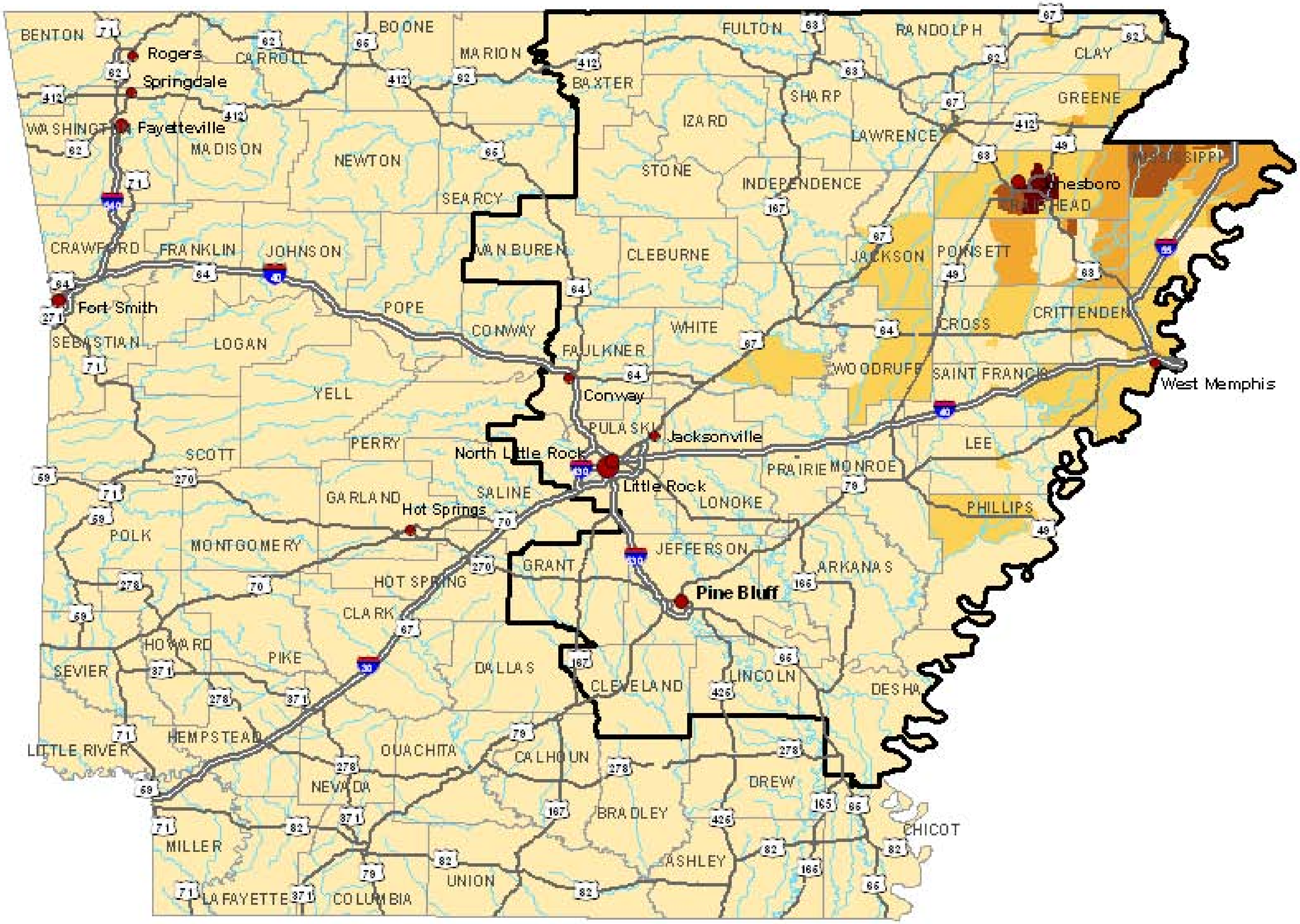
Total Debris - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Brick/ Wood (Thousands of Tons)	Concrete/ Steel (Thousands of Tons)	Total Debris (Thousands of Tons)
Arkansas	15.93	27.10	43.03
Baxter	0.77	0.11	0.87
Clay	97.15	91.99	189.14
Cleburne	1.57	0.37	1.94
Cleveland	1.85	0.42	2.27
Craighead	664.68	884.90	1,549.58
Crittenden	365.53	419.89	785.42
Cross	135.00	149.01	284.01
Desha	3.38	1.46	4.83
Faulkner	1.45	0.23	1.68
Fulton	0.22	0.03	0.25
Grant	1.11	0.24	1.34
Greene	214.87	220.95	435.83
Independence	9.06	3.29	12.35
Izard	0.24	0.03	0.27
Jackson	109.22	114.11	223.33
Jefferson	20.57	7.24	27.80
Lawrence	72.07	73.44	145.51
Lee	62.82	60.25	123.07
Lincoln	2.96	1.06	4.01
Lonoke	23.68	20.64	44.33
Mississippi	700.41	715.07	1,415.48
Monroe	17.98	19.59	37.57
Phillips	87.02	92.42	179.44
Poinsett	315.27	411.49	726.76
Prairie	9.61	12.84	22.45
Pulaski	89.54	38.70	128.24
Randolph	40.66	41.17	81.83
Saint Francis	118.23	126.44	244.67
Sharp	3.93	1.28	5.21
Stone	0.23	0.03	0.26
Van Buren	0.33	0.04	0.37
White	119.86	121.16	241.03
Woodruff	53.61	51.04	104.65

Legend

Total Debris

Thousands of Tons

- 0 - 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 262

Interstate Highways

US Routes

Rivers

Critical Counties

Major Cities

Population in 2000

- 28,000 - 40,000
- 40,001 - 75,000
- 75,001 - 180,000

0 10 20 40 60

Miles

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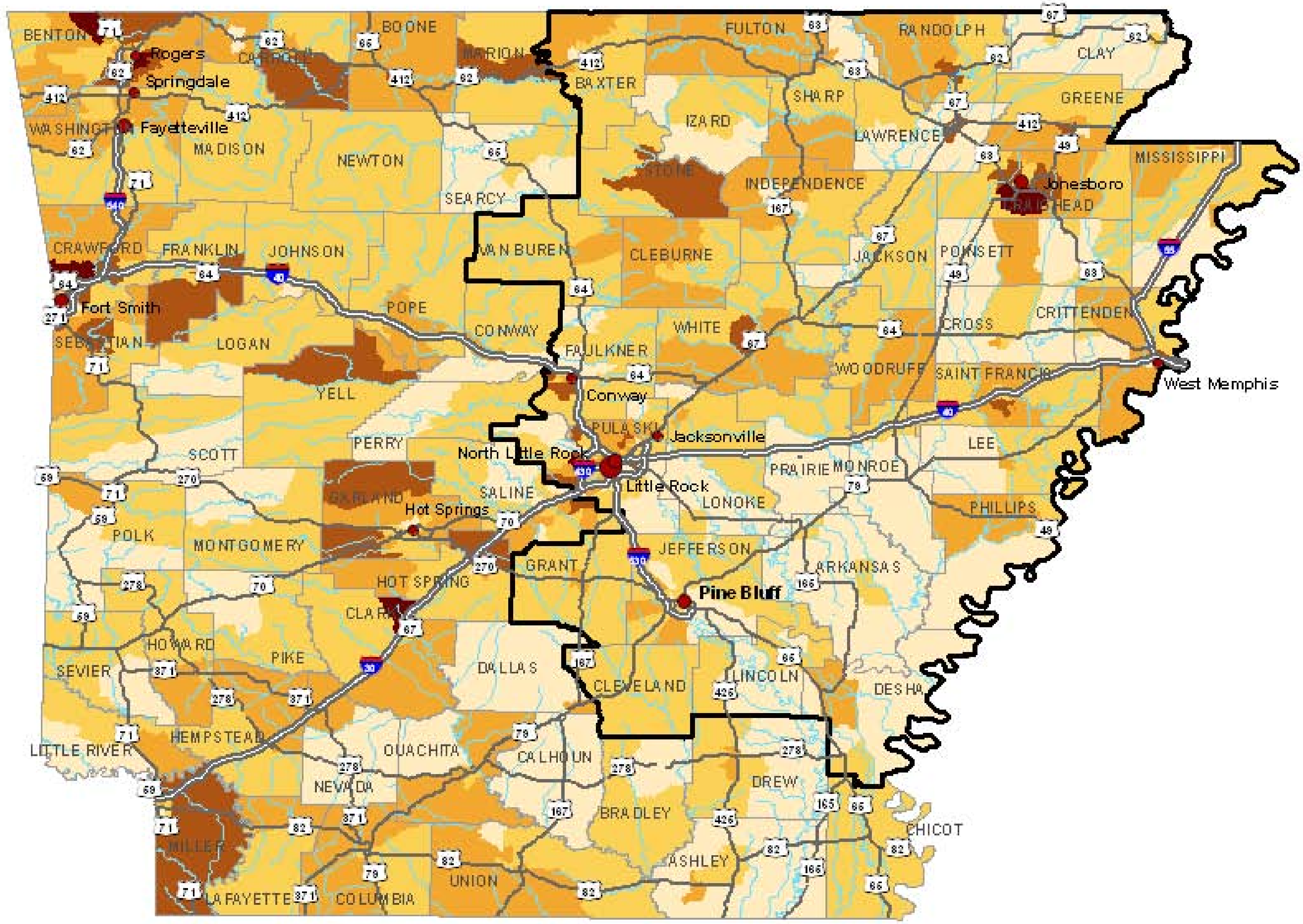
Total Population (Year 2000) - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas
Critical Counties (34)

County	Population
Arkansas	51713
Baxter	70619
Clay	32640
Cleburne	70264
Cleveland	51264
Craighead	131133
Crittenden	67843
Cross	68903
Desha	38867
Faulkner	152615
Fulton	45134
Grant	71969
Greene	70049
Independence	77341
Izard	56696
Jackson	51101
Jefferson	118943
Lawrence	67306
Lee	45206
Lincoln	46074
Lonoke	106907
Mississippi	69939
Monroe	40836
Phillips	38466
Poinsett	62887
Prairie	58747
Pulaski	451849
Randolph	32177
Saint Francis	61021
Sharp	47162
Stone	57982
Van Buren	55272
White	115351
Woodruff	40488

Legend

Major Cities

Population in 2000

- 28,000 - 40,000
- 40,001 - 75,000
- 75,001 - 180,000
- Interstate Highways
- US Routes
- Rivers
- Critical Counties

Total Population

Year 2000 (HAZUS)

- 0 - 3,000
- 3,001 - 5,000
- 5,001 - 7,000
- 7,001 - 9,000
- 9,001 - 11,606

0 10 20 40 60

Miles

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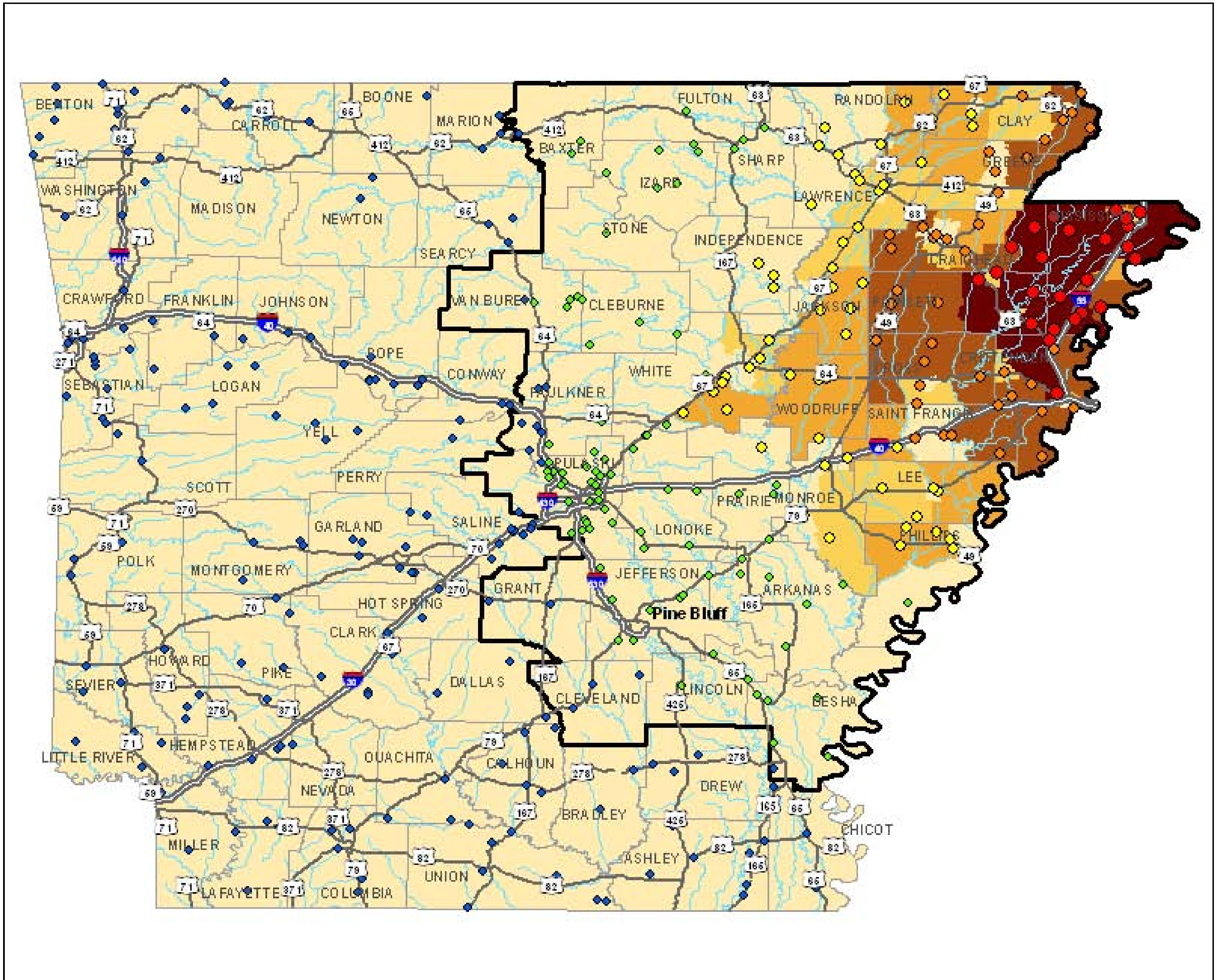
Waste Water Treatment Facilities Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Arkansas Critical Counties (34)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Arkansas	6	0	0
Baxter	4	0	0
Clay	10	7	0
Cleburne	2	0	0
Cleveland	3	0	0
Craighead	11	11	0
Crittenden	9	9	0
Cross	5	5	0
Desha	6	0	0
Faulkner	8	0	0
Fulton	2	0	0
Grant	2	0	0
Greene	4	4	0
Independence	4	0	0
Izard	6	0	0
Jackson	8	0	0
Jefferson	9	0	0
Lawrence	9	0	0
Lee	4	0	0
Lincoln	3	0	0
Lonoke	8	0	0
Mississippi	15	15	3
Monroe	3	0	0
Phillips	7	0	0
Poinsett	9	9	3
Prairie	5	0	0
Pulaski	28	0	0
Randolph	5	0	0
Saint Francis	8	6	0
Sharp	3	0	0
Stone	1	0	0
Van Buren	6	0	0
White	12	0	0
Woodruff	4	0	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Likely
- Highly Likely

Waste Water Distribution Lines

No. of Leaks

- 0 - 50
- 51 - 100
- 101 - 200
- 201 - 500
- 501 - 1,230

- Critical Counties
- Interstate Highways
- US Routes
- Rivers

0 10 20 40 60
Miles

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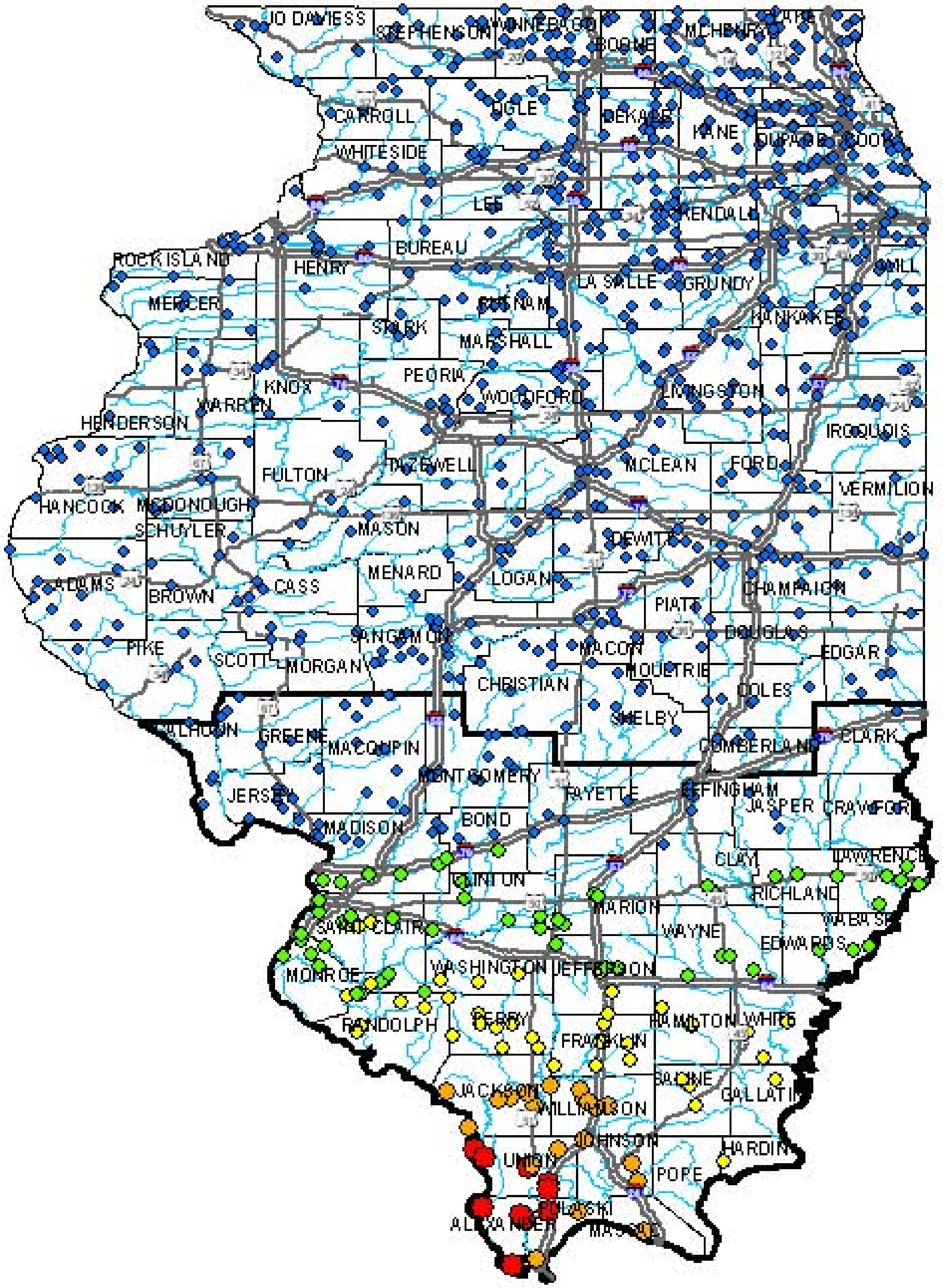
Airport Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

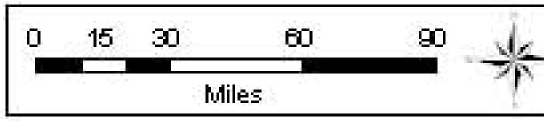
County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	5	5	3
Bond	4	0	0
Calhoun	4	0	0
Clark	2	0	0
Clay	3	0	0
Clinton	5	0	0
Crawford	2	0	0
Edwards	1	0	0
Effingham	4	0	0
Fayette	4	0	0
Franklin	7	0	0
Gallatin	1	0	0
Greene	7	0	0
Hamilton	3	0	0
Hardin	1	0	0
Jackson	7	7	0
Jasper	3	0	0
Jefferson	6	0	0
Jersey	7	0	0
Johnson	3	3	0
Lawrence	6	0	0
Macoupin	12	0	0
Madison	14	0	0
Marion	4	0	0
Massac	1	1	0
Monroe	7	0	0
Montgomery	12	0	0
Perry	8	0	0
Pulaski	2	2	1
Randolph	7	0	0
Richland	2	0	0
Saint Clair	13	0	0
Saline	3	0	0
Union	7	7	5
Wabash	2	0	0
Washington	4	0	0
Wayne	4	0	0
White	3	0	0
Williamson	5	5	0
Pope	0	0	0

Legend

Airport Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- US Routes
- Interstates
- Critical Counties
- Rivers



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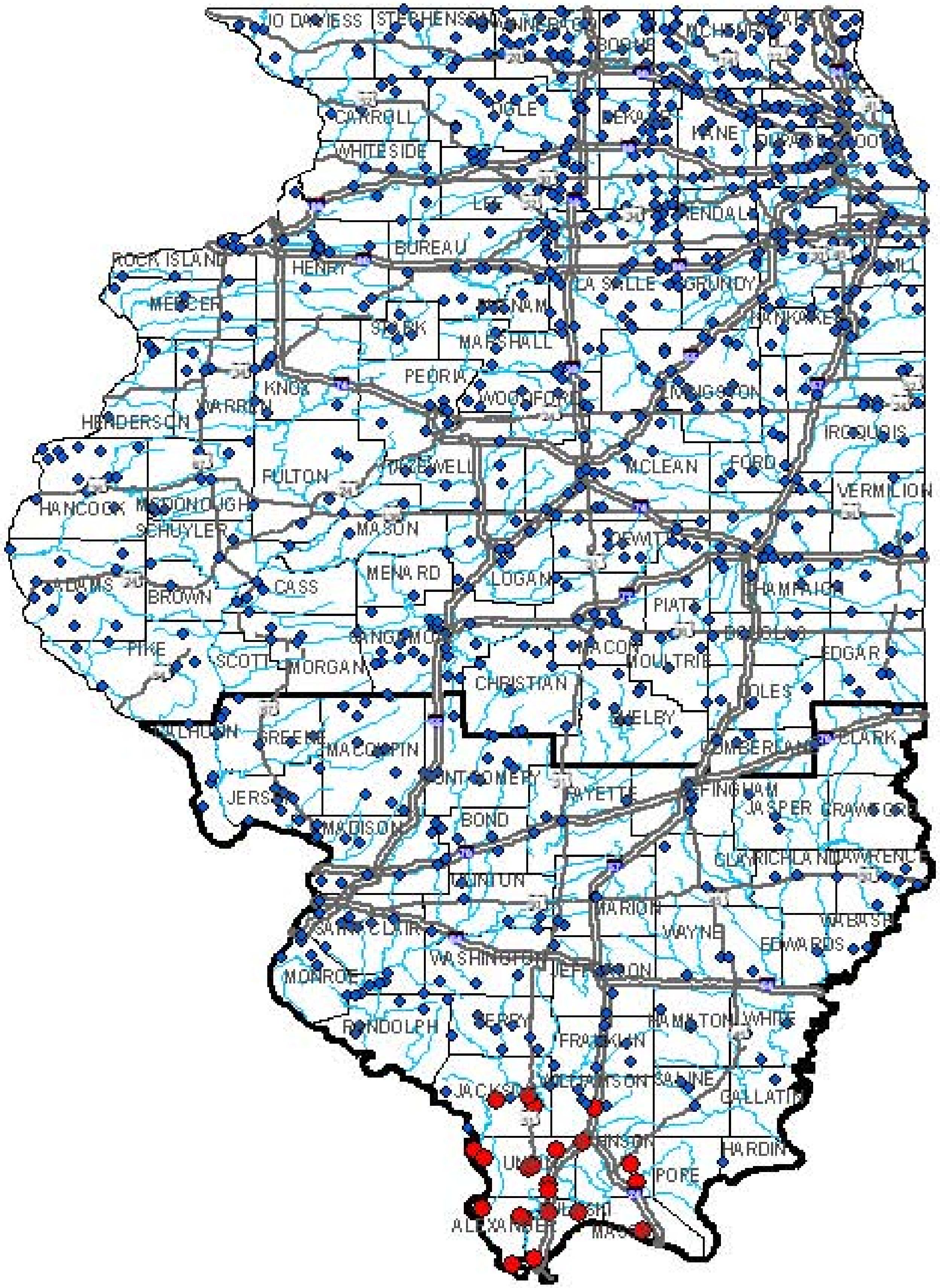
Airport Functionality - New Madrid Seismic Zone: M7.7 Event

Febraruy 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Alexander	0	5
Bond	4	4
Calhoun	4	4
Clark	2	2
Clay	3	3
Clinton	5	5
Crawford	2	2
Edwards	1	1
Effingham	4	4
Fayette	4	4
Franklin	7	7
Gallatin	1	1
Greene	7	7
Hamilton	3	3
Hardin	1	1
Jackson	4	7
Jasper	3	3
Jefferson	6	6
Jersey	7	7
Johnson	0	3
Lawrence	6	6
Macoupin	12	12
Madison	14	14
Marion	4	4
Massac	0	1
Monroe	7	7
Montgomery	12	12
Perry	8	8
Pulaski	0	2
Randolph	7	7
Richland	2	2
Saint Clair	13	13
Saline	3	3
Union	0	7
Wabash	2	2
Washington	4	4
Wayne	4	4
White	3	3
Williamson	4	5
Pope	0	0

Legend

Airport Functionality

Day 1

- Not Functional
- Functional
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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Worst Case Casualties (2 AM) - New Madrid Seismic Zone: M7.7 Event

February 2008

State of Illinois Critical Counties (40)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Alexander	1,811	93	1,905
Bond	1	0	1
Calhoun	0	0	0
Clark	1	0	1
Clay	6	0	6
Clinton	186	8	193
Crawford	1	0	1
Edwards	13	0	13
Effingham	1	0	1
Fayette	1	0	1
Franklin	101	4	104
Gallatin	9	0	9
Greene	1	0	1
Hamilton	20	1	21
Hardin	3	0	3
Jackson	882	39	921
Jasper	0	0	0
Jefferson	63	2	65
Jersey	1	0	1
Johnson	434	20	454
Lawrence	160	7	167
Macoupin	1	0	1
Madison	1,515	66	1,581
Marion	10	0	10
Massac	1,273	63	1,336
Monroe	25	1	26
Montgomery	1	0	1
Perry	68	2	71
Pope	33	1	34
Pulaski	1,181	59	1,240
Randolph	383	17	400
Richland	0	0	0
Saint Clair	2,170	93	2,263
Saline	36	1	37
Union	2,248	128	2,375
Wabash	72	3	75
Washington	16	0	16
Wayne	3	0	3
White	32	1	33
Williamson	365	14	379

Legend

Worst Case Casualties (2 AM)

- 0 - 5
- 6 - 50
- 51 - 150
- 151 - 350
- 351 - 731

- Rivers
- Critical Counties
- Interstates
- US Routes

Major Cities

- 80,000 - 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000

0 15 30 60 90
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

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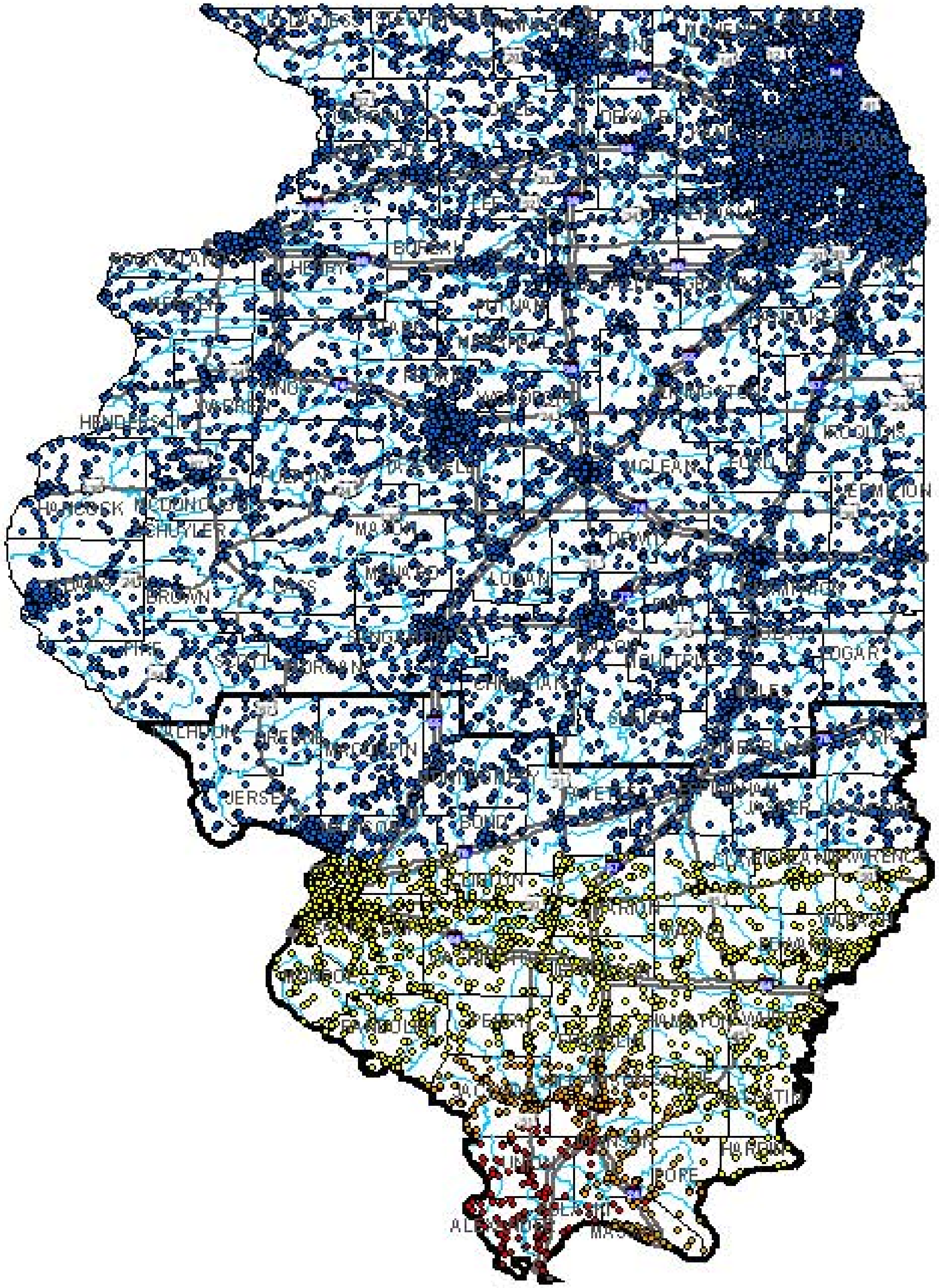
Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	112	112	33
Bond	97	0	0
Calhoun	41	0	0
Clark	156	0	0
Clay	111	0	0
Clinton	254	0	0
Crawford	174	0	0
Edwards	77	0	0
Effingham	237	0	0
Fayette	168	0	0
Franklin	194	61	0
Gallatin	59	0	0
Greene	95	0	0
Hamilton	91	0	0
Hardin	30	0	0
Jackson	338	338	0
Jasper	97	0	0
Jefferson	237	0	0
Jersey	78	0	0
Johnson	125	125	0
Lawrence	109	0	0
Macoupin	286	0	0
Madison	781	0	0
Marion	239	0	0
Massac	128	128	0
Monroe	129	0	0
Montgomery	240	0	0
Perry	155	0	0
Pope	105	105	0
Pulaski	86	86	0
Randolph	248	0	0
Richland	118	0	0
Saint Clair	811	0	0
Saline	167	16	0
Union	177	177	33
Wabash	104	0	0
Washington	161	0	0
Wayne	161	0	0
White	187	0	0
Williamson	303	303	0

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

US Routes

Interstates

Critical Counties

Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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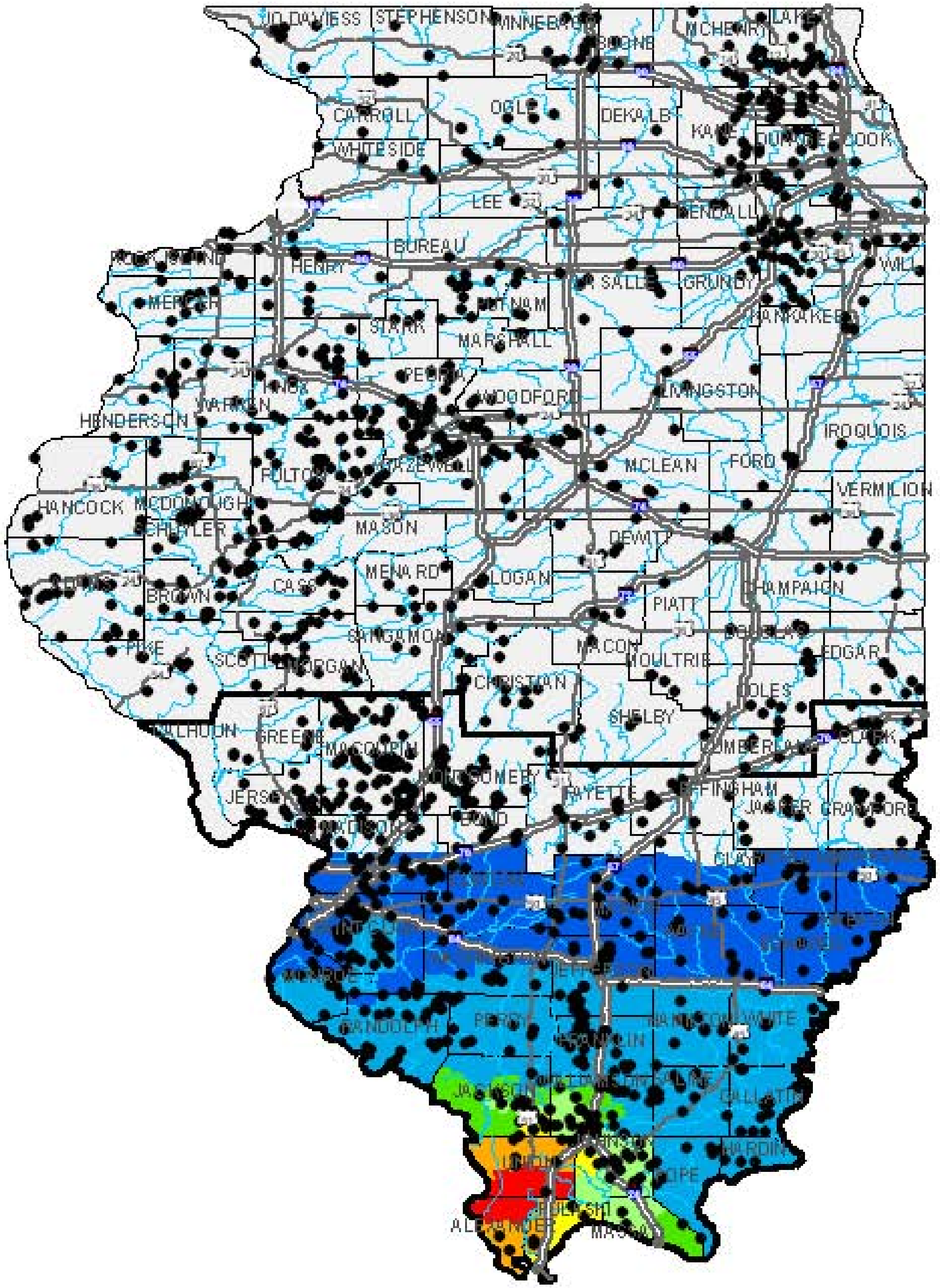
Dams - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Facilities
Alexander	2
Bond	12
Clark	16
Clay	11
Clinton	16
Crawford	9
Edwards	5
Effingham	10
Fayette	13
Franklin	38
Gallatin	16
Greene	10
Hamilton	11
Hardin	4
Jackson	19
Jasper	8
Jefferson	34
Jersey	18
Johnson	18
Lawrence	2
Macoupin	87
Madison	48
Marion	20
Massac	4
Monroe	21
Montgomery	40
Perry	10
Pope	6
Pulaski	4
Randolph	34
Richland	10
Saint Clair	47
Saline	20
Union	7
Wabash	4
Washington	12
Wayne	11
White	7
Williamson	41
Calhoun	

Legend

- Dams

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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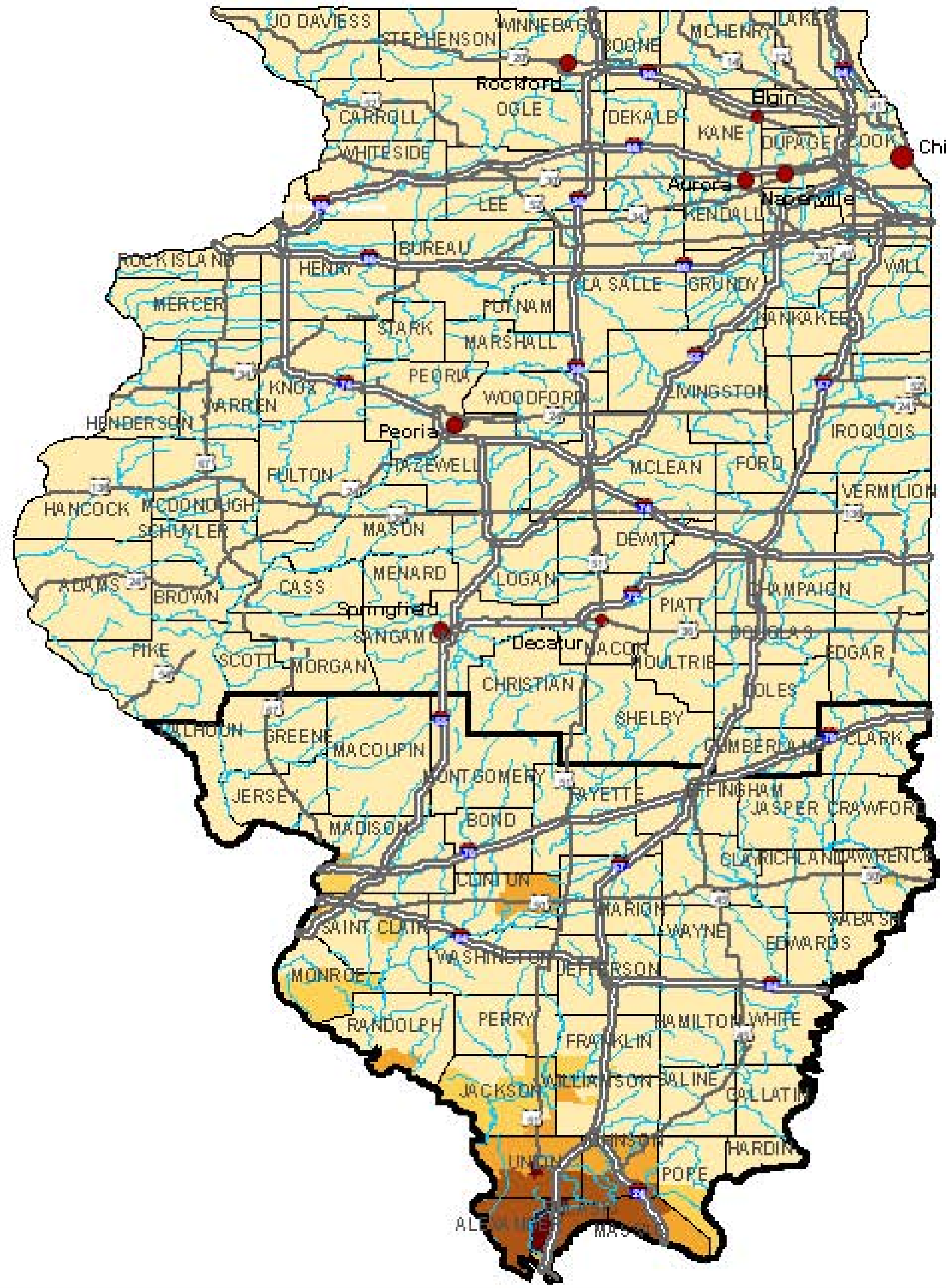
Total Debris - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Brick/ Wood	Concrete/ Steel	Total Debris
Alexander	163.74	175.73	339.47
Bond	0.30	0.04	0.34
Calhoun	0.12	0.01	0.13
Clark	0.38	0.05	0.44
Clay	3.34	1.51	4.85
Clinton	20.51	19.04	39.55
Crawford	0.37	0.04	0.41
Edwards	4.57	2.26	6.83
Effingham	0.80	0.13	0.93
Fayette	0.58	0.08	0.66
Franklin	18.21	10.51	28.72
Gallatin	2.29	1.00	3.28
Greene	0.41	0.04	0.45
Hamilton	3.93	2.38	6.32
Hardin	1.39	0.35	1.74
Jackson	86.61	79.16	165.77
Jasper	0.18	0.02	0.20
Jefferson	15.59	8.87	24.46
Jersey	0.40	0.05	0.44
Johnson	58.09	57.11	115.20
Lawrence	17.90	19.31	37.21
Macoupin	0.91	0.11	1.02
Madison	133.31	122.96	256.27
Marion	5.68	1.83	7.50
Massac	132.85	143.30	276.15
Monroe	6.19	2.35	8.54
Montgomery	0.67	0.07	0.74
Perry	12.61	7.81	20.42
Pope	8.54	6.82	15.36
Pulaski	113.89	117.84	231.73
Randolph	41.14	38.37	79.51
Richland	0.32	0.04	0.36
Saint Clair	192.04	155.48	347.52
Saline	10.24	5.14	15.38
Union	219.36	249.61	468.97
Wabash	10.04	8.12	18.16
Washington	5.08	2.13	7.21
Wayne	1.24	0.36	1.60
White	7.45	3.74	11.19
Williamson	47.88	33.57	81.45

Legend

Total Debris

Thousands of Tons

- 0 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 178
- Rivers
- Critical Counties
- Interstates
- US Routes

Major Cities

- 80,000 - 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000

0 15 30 60 90
Miles

Mid-America Earthquake Center

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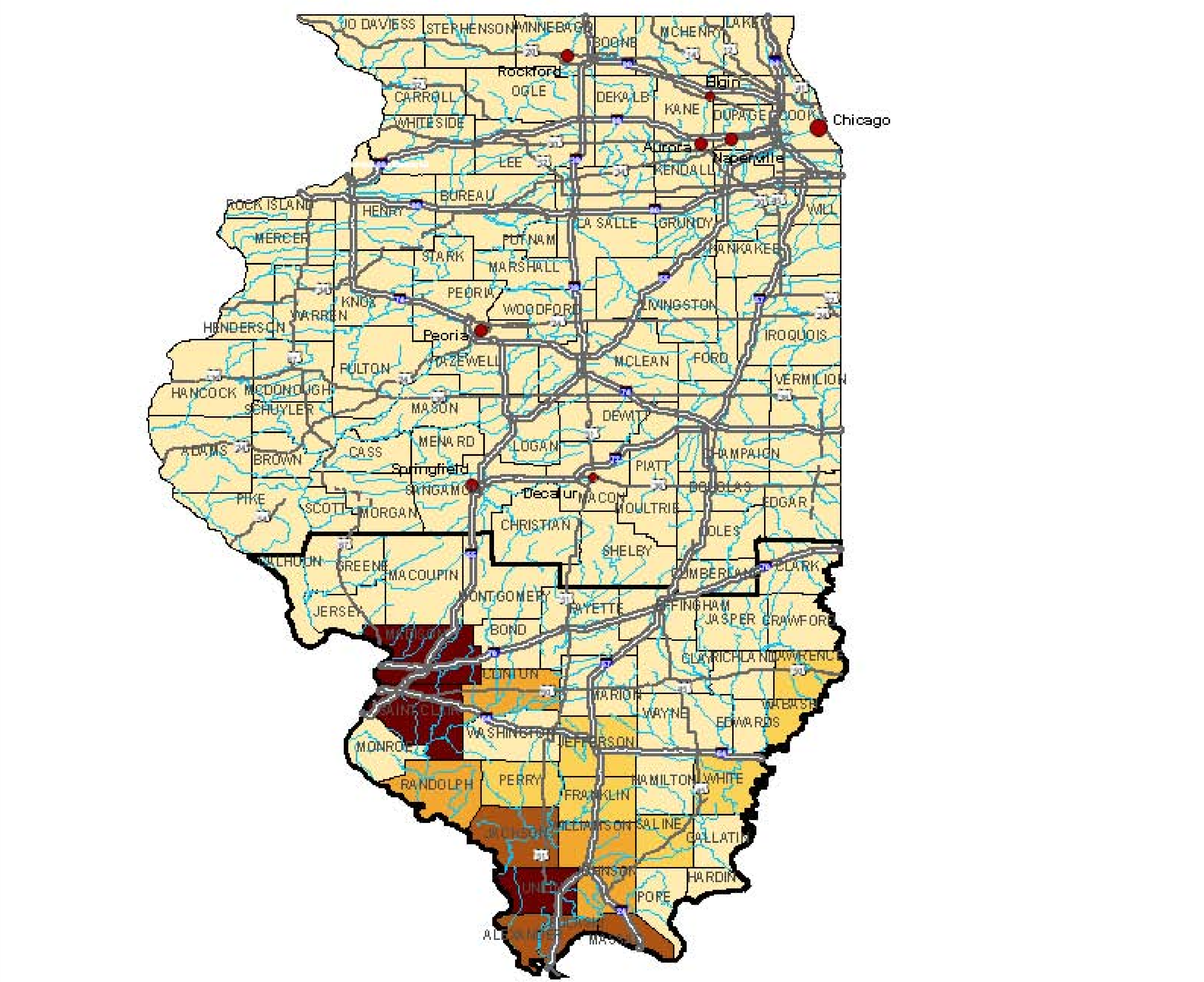
Displaced Population - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Displaced Residences	Displaced Population
Alexander	2237	5633
Bond	0	0
Calhoun	0	0
Clark	0	0
Clay	0	1
Clinton	365	1016
Crawford	0	0
Edwards	0	0
Effingham	0	0
Fayette	0	0
Franklin	176	417
Gallatin	11	25
Greene	0	0
Hamilton	31	77
Hardin	0	0
Jackson	1662	4090
Jasper	0	0
Jefferson	72	188
Jersey	0	0
Johnson	549	1689
Lawrence	312	763
Macoupin	0	0
Madison	3034	7706
Marion	1	2
Massac	2235	5412
Monroe	30	81
Montgomery	0	0
Perry	107	290
Pope	33	81
Pulaski	1402	3962
Randolph	649	1819
Richland	0	0
Saint Clair	3666	9696
Saline	44	107
Union	2568	6445
Wabash	132	329
Washington	15	38
Wayne	0	0
White	47	110
Williamson	746	1804

Legend

Displaced Population

- 0 - 100
- 101 - 1,000
- 1,001 - 3,000
- 3,001 - 6,000
- 6,001 - 10,000
- US Routes
- Interstates
- Critical Counties
- Rivers

Major Cities

- 80,000 - 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000

0 15 30 60 90
Miles

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Mid-America Earthquake Center
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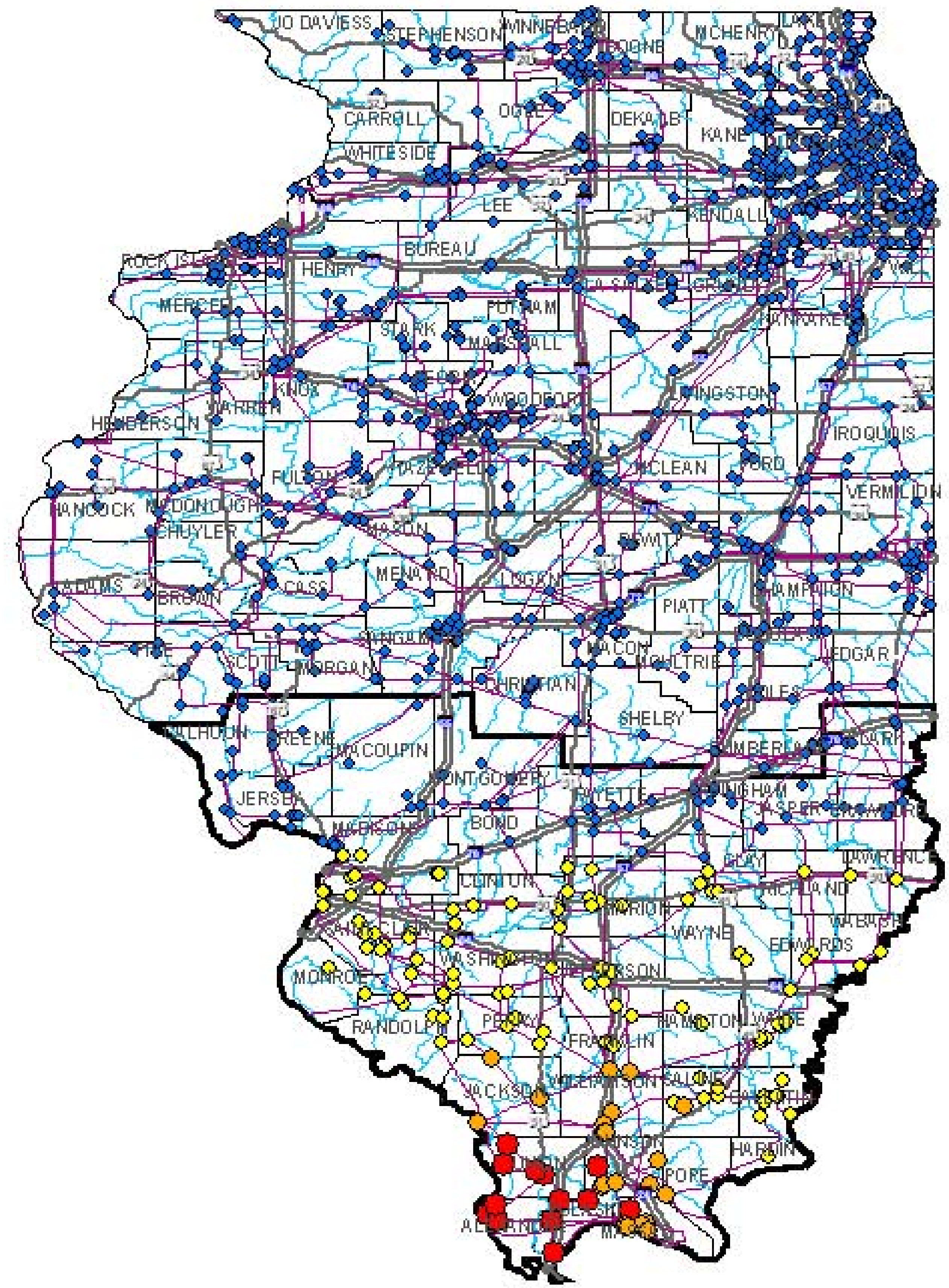
Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	3	3	3
Bond	1	0	0
Calhoun	3	0	0
Clark	11	0	0
Clay	25	0	0
Clinton	10	0	0
Crawford	13	0	0
Edwards	2	0	0
Effingham	15	0	0
Fayette	11	0	0
Franklin	9	2	0
Gallatin	7	0	0
Greene	10	0	0
Hamilton	3	0	0
Hardin	1	0	0
Jackson	4	4	0
Jasper	5	0	0
Jefferson	5	0	0
Jersey	9	0	0
Johnson	7	7	0
Lawrence	2	0	0
Macoupin	5	0	0
Madison	22	0	0
Marion	11	0	0
Massac	20	20	0
Monroe	2	0	0
Montgomery	7	0	0
Perry	14	0	0
Pope	1	1	0
Pulaski	3	3	0
Randolph	16	0	0
Richland	1	0	0
Saint Clair	25	0	0
Saline	9	1	0
Union	4	4	0
Wabash	2	0	0
Washington	11	0	0
Wayne	2	0	0
White	9	0	0
Williamson	14	14	0

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Electric Tranmission Lines
- US Routes
- Interstates
- Critical Counties
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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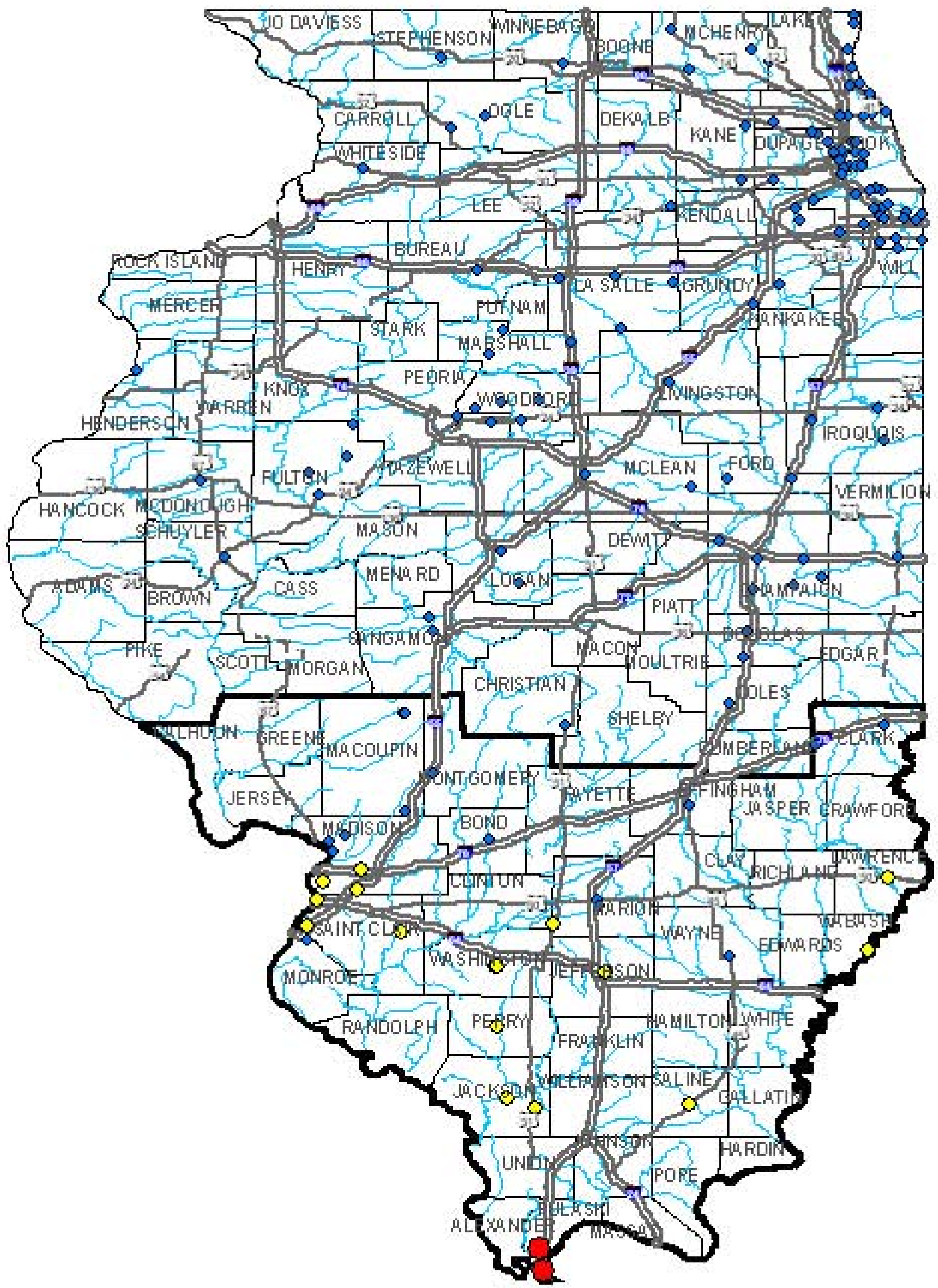
Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	1	1	1
Bond	1	0	0
Clark	2	0	0
Effingham	1	0	0
Jackson	2	0	0
Jefferson	1	0	0
Lawrence	1	0	0
Macoupin	3	0	0
Madison	6	0	0
Marion	3	0	0
Monroe	1	0	0
Montgomery	1	0	0
Perry	1	0	0
Pulaski	1	1	1
Saint Clair	3	0	0
Saline	1	0	0
Wabash	1	0	0
Washington	2	0	0
Wayne	1	0	0
Calhoun	0	0	0
Clay	0	0	0
Clinton	0	0	0
Crawford	0	0	0
Edwards	0	0	0
Fayette	0	0	0
Franklin	0	0	0
Gallatin	0	0	0
Greene	0	0	0
Hamilton	0	0	0
Hardin	0	0	0
Jasper	0	0	0
Jersey	0	0	0
Johnson	0	0	0
Massac	0	0	0
Pope	0	0	0
Randolph	0	0	0
Richland	0	0	0
Union	0	0	0
White	0	0	0
Williamson	0	0	0

Legend

Emergency Operation Centers

At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- US Routes
- Interstates
- Critical Counties
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

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Theresa Jefferson, Principal Investigator

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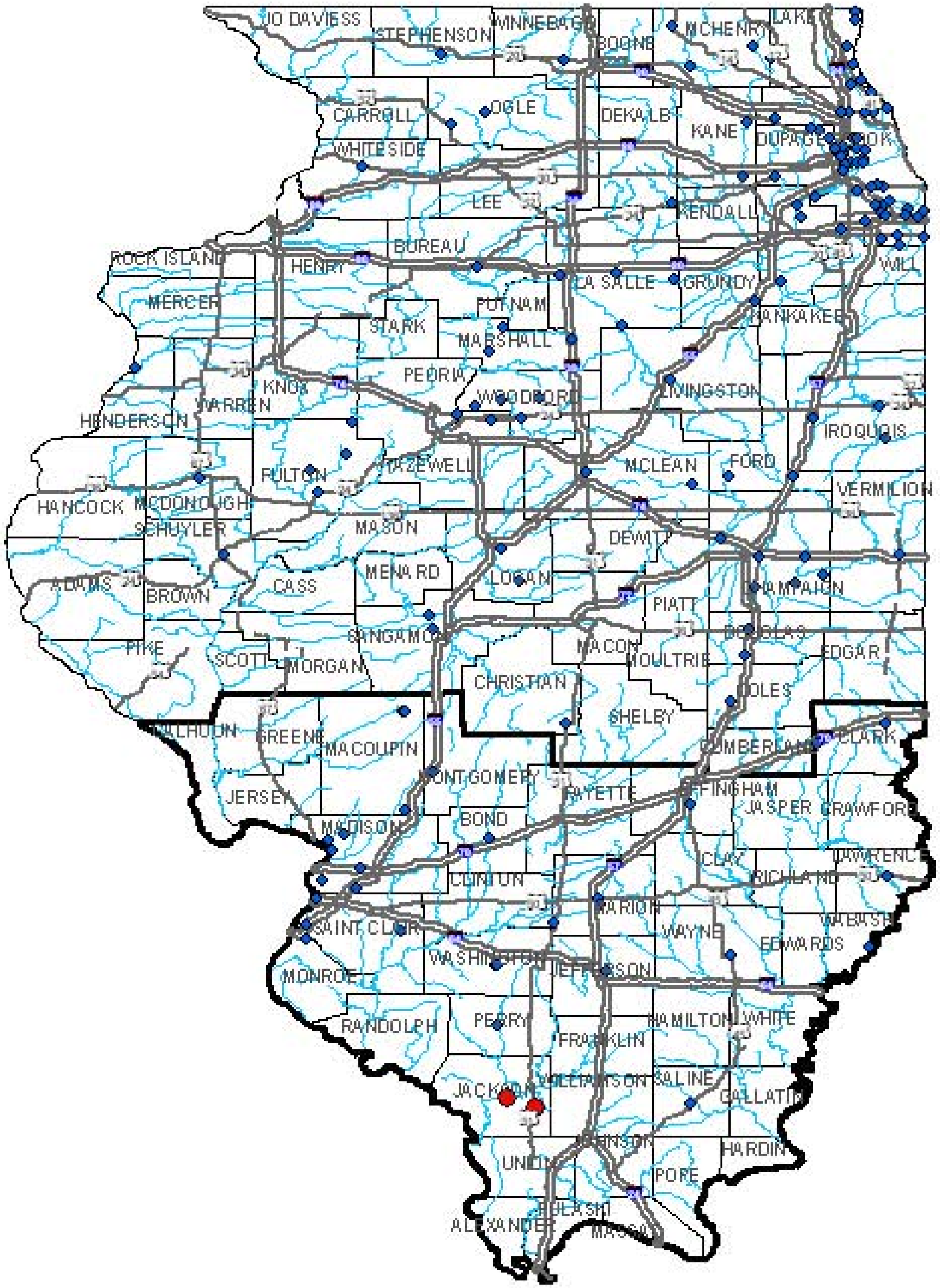
Emergency Oper. Center Functionality - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Alexander	0	1
Bond	1	1
Clark	2	2
Effingham	1	1
Jackson	0	2
Jefferson	1	1
Lawrence	1	1
Macoupin	3	3
Madison	6	6
Marion	3	3
Monroe	1	1
Montgomery	1	1
Perry	1	1
Pulaski	0	1
Saint Clair	3	3
Saline	1	1
Wabash	1	1
Washington	2	2
Wayne	1	1
Calhoun	0	0
Clay	0	0
Clinton	0	0
Crawford	0	0
Edwards	0	0
Fayette	0	0
Franklin	0	0
Gallatin	0	0
Greene	0	0
Hamilton	0	0
Hardin	0	0
Jasper	0	0
Jersey	0	0
Johnson	0	0
Massac	0	0
Pope	0	0
Randolph	0	0
Richland	0	0
Union	0	0
White	0	0
Williamson	0	0

Legend

Emergency Operation Centers

Day 1

- Not Functional
- Functional
- Rivers
- Critical Counties
- Interstates
- US Routes

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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Ferry Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008

State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Calhoun	2	2	2
Greene	2	2	2
Hardin	1	1	1
Jersey	2	2	2
Randolph	1	1	1
Alexander	0	0	0
Bond	0	0	0
Clark	0	0	0
Clay	0	0	0
Clinton	0	0	0
Crawford	0	0	0
Edwards	0	0	0
Effingham	0	0	0
Fayette	0	0	0
Franklin	0	0	0
Gallatin	0	0	0
Hamilton	0	0	0
Jackson	0	0	0
Jasper	0	0	0
Jefferson	0	0	0
Johnson	0	0	0
Lawrence	0	0	0
Macoupin	0	0	0
Madison	0	0	0
Marion	0	0	0
Massac	0	0	0
Monroe	0	0	0
Montgomery	0	0	0
Perry	0	0	0
Pope	0	0	0
Pulaski	0	0	0
Richland	0	0	0
Saint Clair	0	0	0
Saline	0	0	0
Union	0	0	0
Wabash	0	0	0
Washington	0	0	0
Wayne	0	0	0
White	0	0	0
Williamson	0	0	0

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- US Routes
- Interstates
- Critical Counties
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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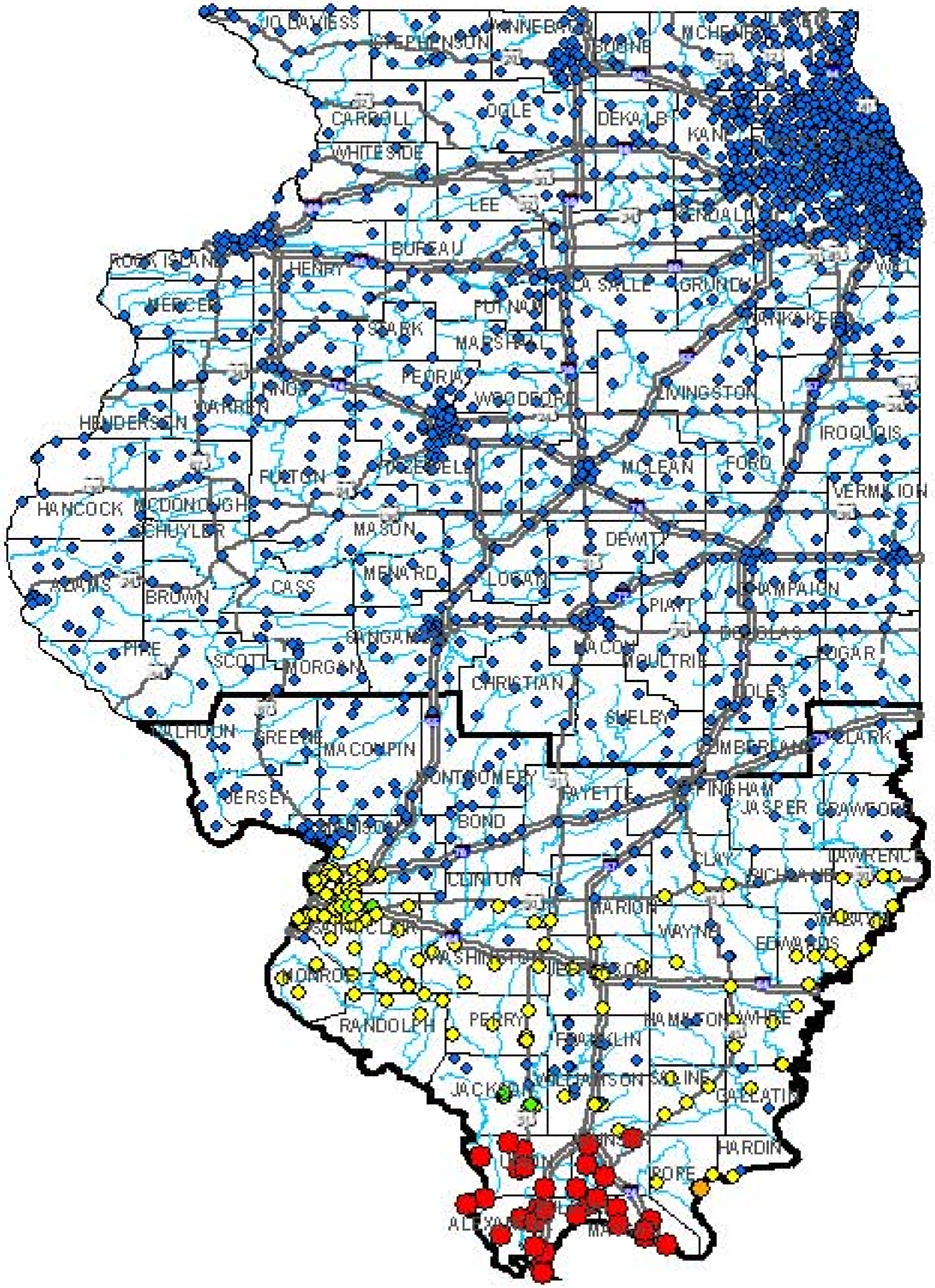
Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	7	7	7
Bond	8	0	0
Calhoun	5	0	0
Clark	4	0	0
Clay	5	0	0
Clinton	6	0	0
Crawford	5	0	0
Edwards	4	0	0
Effingham	11	0	0
Fayette	6	0	0
Franklin	14	0	0
Gallatin	6	0	0
Greene	8	0	0
Hamilton	3	0	0
Hardin	3	0	0
Jackson	12	0	0
Jasper	3	0	0
Jefferson	12	0	0
Jersey	4	0	0
Johnson	6	6	5
Lawrence	5	0	0
Macoupin	16	0	0
Madison	64	0	0
Marion	4	0	0
Massac	7	7	4
Monroe	7	0	0
Montgomery	12	0	0
Perry	7	0	0
Pope	4	2	0
Pulaski	8	8	8
Randolph	6	0	0
Richland	5	0	0
Saint Clair	43	0	0
Saline	4	0	0
Union	8	8	8
Wabash	5	0	0
Washington	7	0	0
Wayne	6	0	0
White	6	0	0
Williamson	10	0	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- US Routes
- Interstates
- Critical Counties
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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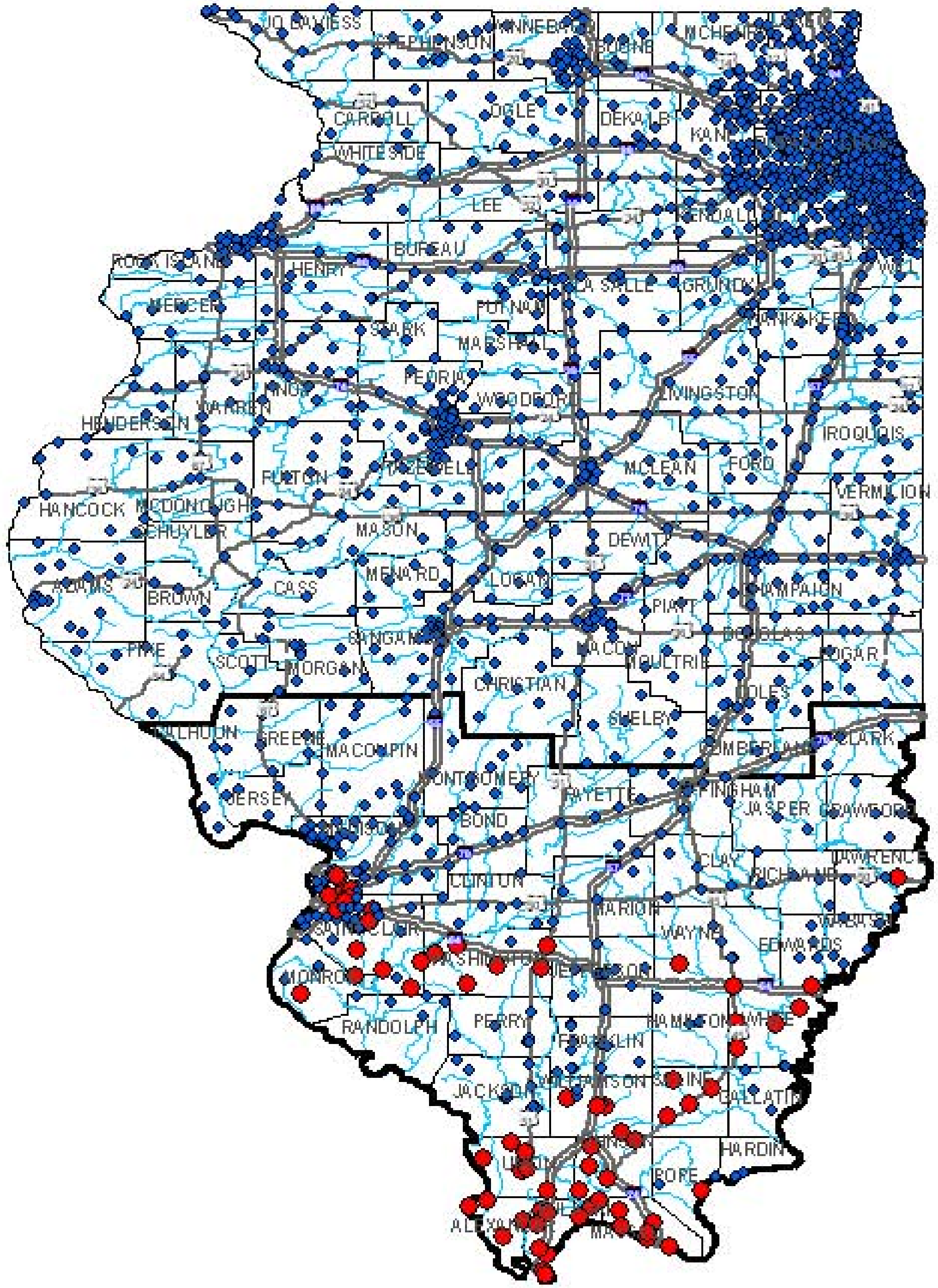
Fire Station Functionality - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Alexander	0	7
Bond	8	8
Calhoun	5	5
Clark	4	4
Clay	5	5
Clinton	6	6
Crawford	5	5
Edwards	4	4
Effingham	11	11
Fayette	6	6
Franklin	14	14
Gallatin	6	6
Greene	8	8
Hamilton	3	3
Hardin	3	3
Jackson	12	12
Jasper	3	3
Jefferson	12	12
Jersey	4	4
Johnson	0	6
Lawrence	4	5
Macoupin	16	16
Madison	59	64
Marion	4	4
Massac	0	7
Monroe	5	7
Montgomery	12	12
Perry	7	7
Pope	2	4
Pulaski	0	8
Randolph	6	6
Richland	5	5
Saint Clair	30	43
Saline	0	4
Union	0	8
Wabash	5	5
Washington	1	7
Wayne	5	6
White	0	6
Williamson	6	10

Legend

Fire Station Functionality

Day 1

- Not Functional
- Functional
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90
Miles

Mid-America Earthquake Center

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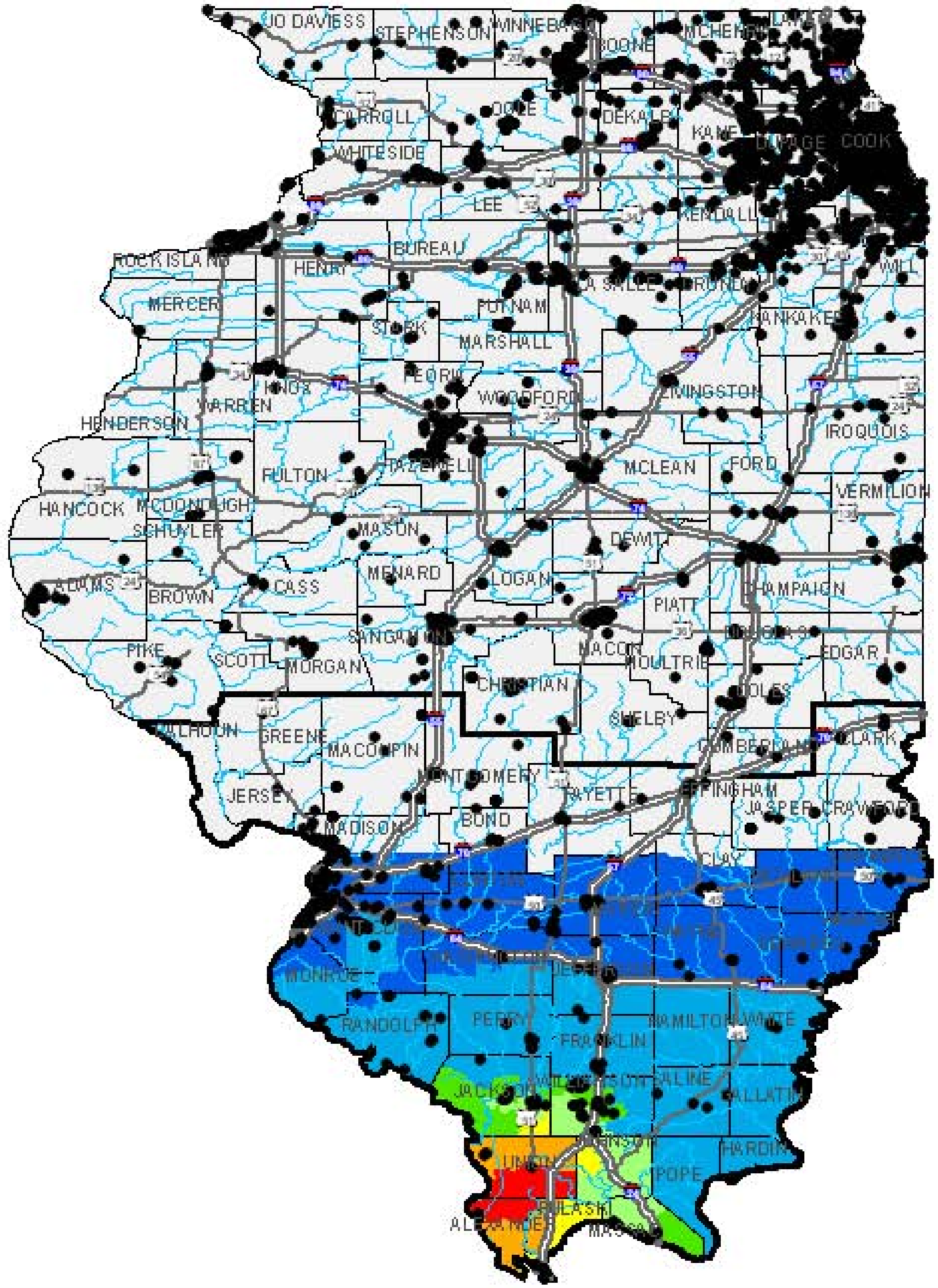
Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Facilities
Alexander	10
Bond	8
Calhoun	0
Clark	9
Clay	15
Clinton	14
Crawford	39
Edwards	3
Effingham	25
Fayette	10
Franklin	10
Gallatin	0
Greene	1
Hamilton	0
Hardin	6
Jackson	20
Jasper	17
Jefferson	18
Jersey	2
Johnson	0
Lawrence	4
Macoupin	20
Madison	268
Marion	30
Massac	22
Monroe	2
Montgomery	24
Perry	11
Pope	0
Pulaski	0
Randolph	32
Richland	3
Saint Clair	326
Saline	4
Union	4
Wabash	8
Washington	14
Wayne	8
White	4
Williamson	44

Legend

• Hazardous Materials Facilities

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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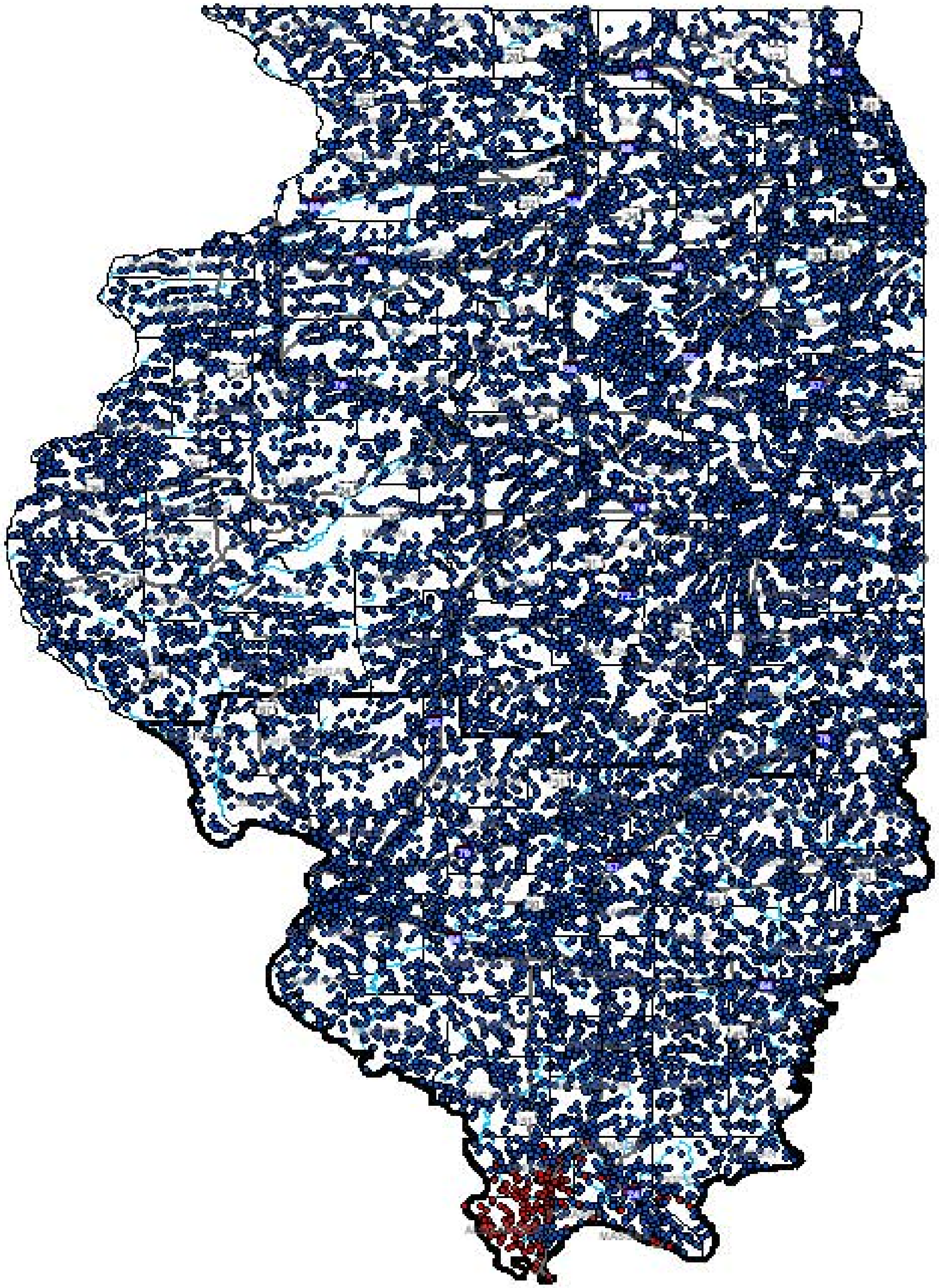
Highway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Alexander	0	91
Bond	150	150
Calhoun	58	58
Clark	180	180
Clay	152	152
Clinton	175	175
Crawford	170	170
Edwards	80	80
Effingham	217	217
Fayette	320	320
Franklin	238	238
Gallatin	71	71
Greene	140	140
Hamilton	167	167
Hardin	44	44
Jackson	177	177
Jasper	151	151
Jefferson	213	213
Jersey	90	90
Johnson	89	103
Lawrence	148	148
Macoupin	206	206
Madison	396	396
Marion	247	247
Massac	112	118
Monroe	102	102
Montgomery	212	212
Perry	124	124
Pope	65	71
Pulaski	38	93
Randolph	136	136
Richland	131	131
Saint Clair	383	383
Saline	164	164
Union	89	178
Wabash	76	76
Washington	202	202
Wayne	234	234
White	197	197
Williamson	149	149

Legend

Highway Bridge Functionality

Day 1

- Not Functional
- Functional
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

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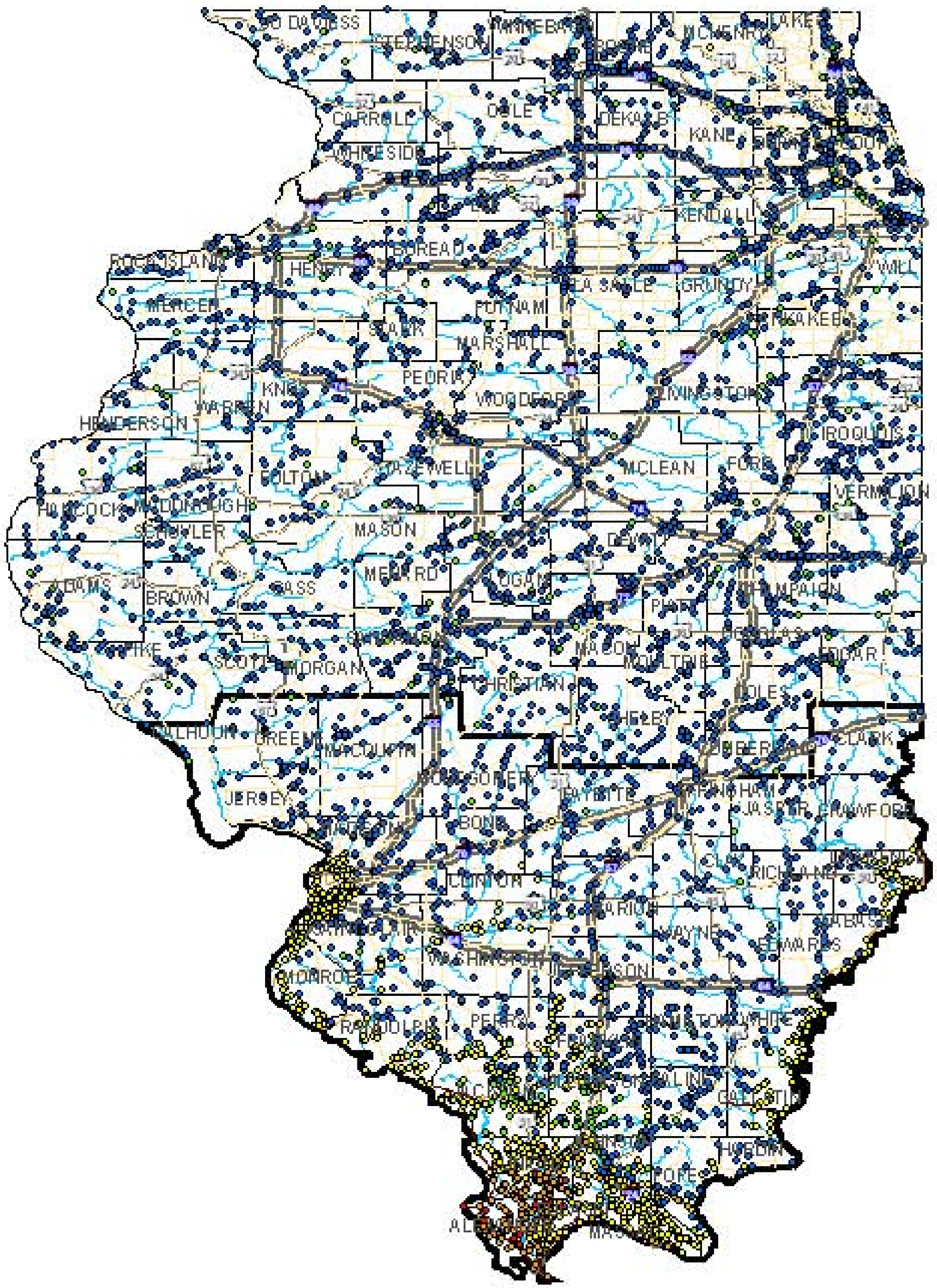
Highway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	91	91	42
Bond	150	0	0
Calhoun	58	0	0
Clark	180	0	0
Clay	152	0	0
Clinton	175	0	0
Crawford	170	0	0
Edwards	80	0	0
Effingham	217	0	0
Fayette	320	0	0
Franklin	238	0	0
Gallatin	71	0	0
Greene	140	0	0
Hamilton	167	0	0
Hardin	44	0	0
Jackson	177	0	0
Jasper	151	0	0
Jefferson	213	0	0
Jersey	90	0	0
Johnson	103	15	0
Lawrence	148	0	0
Macoupin	206	0	0
Madison	396	0	0
Marion	247	0	0
Massac	118	8	0
Monroe	102	0	0
Montgomery	212	0	0
Perry	124	0	0
Pope	71	6	0
Rulaski	93	55	16
Randolph	136	0	0
Richland	131	0	0
Saint Clair	383	0	0
Saline	164	0	0
Union	178	89	13
Wabash	76	0	0
Washington	202	0	0
Wayne	234	0	0
White	197	0	0
Williamson	149	0	0

Legend

Highway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

US Routes

Interstates

Critical Counties

Rivers

Highway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood

0 15 30 60 90

Miles

Mid-America Earthquake Center

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Hospital Damage - New Madrid Seismic Zone: M7.7 Event

February 2008

State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Bond	1	0	0
Clay	1	0	0
Clinton	2	0	0
Crawford	1	0	0
Effingham	1	0	0
Fayette	1	0	0
Franklin	1	0	0
Greene	1	0	0
Hamilton	1	0	0
Hardin	1	0	0
Jackson	2	0	0
Jefferson	2	0	0
Jersey	1	0	0
Lawrence	1	0	0
Macoupin	2	0	0
Madison	7	0	0
Marion	2	0	0
Massac	1	1	1
Montgomery	2	0	0
Perry	2	0	0
Randolph	4	0	0
Richland	1	0	0
Saint Clair	5	0	0
Saline	2	0	0
Union	2	2	0
Wabash	1	0	0
Washington	1	0	0
Wayne	1	0	0
Williamson	3	0	0
Alexander	0	0	0
Calhoun	0	0	0
Clark	0	0	0
Edwards	0	0	0
Gallatin	0	0	0
Jasper	0	0	0
Johnson	0	0	0
Monroe	0	0	0
Pope	0	0	0
Pulaski	0	0	0
White	0	0	0

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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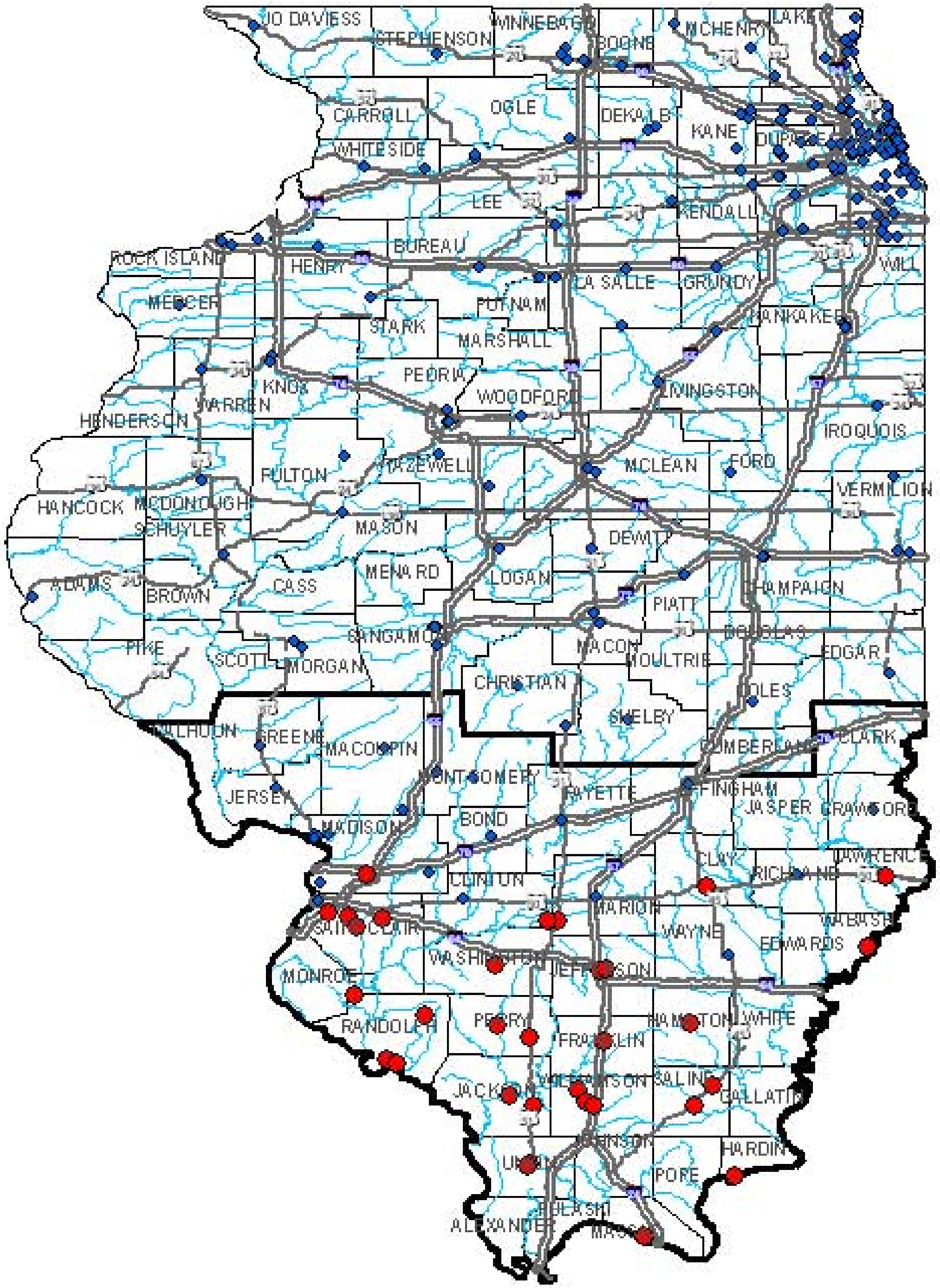
Hospital Functionality - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Bond	1	1
Clay	0	1
Clinton	1	2
Crawford	1	1
Effingham	1	1
Fayette	1	1
Franklin	0	1
Greene	1	1
Hamilton	0	1
Hardin	0	1
Jackson	0	2
Jefferson	0	2
Jersey	1	1
Lawrence	0	1
Macoupin	2	2
Madison	6	7
Marion	1	2
Massac	0	1
Montgomery	2	2
Perry	0	2
Randolph	0	4
Richland	1	1
Saint Clair	1	5
Saline	0	2
Union	0	2
Wabash	0	1
Washington	0	1
Wayne	1	1
Williamson	0	3
Alexander	0	0
Calhoun	0	0
Clark	0	0
Edwards	0	0
Gallatin	0	0
Jasper	0	0
Johnson	0	0
Monroe	0	0
Pope	0	0
Pulaski	0	0
White	0	0

Legend

Hospital Functionality

Day 1

- Not Functional
- Functional
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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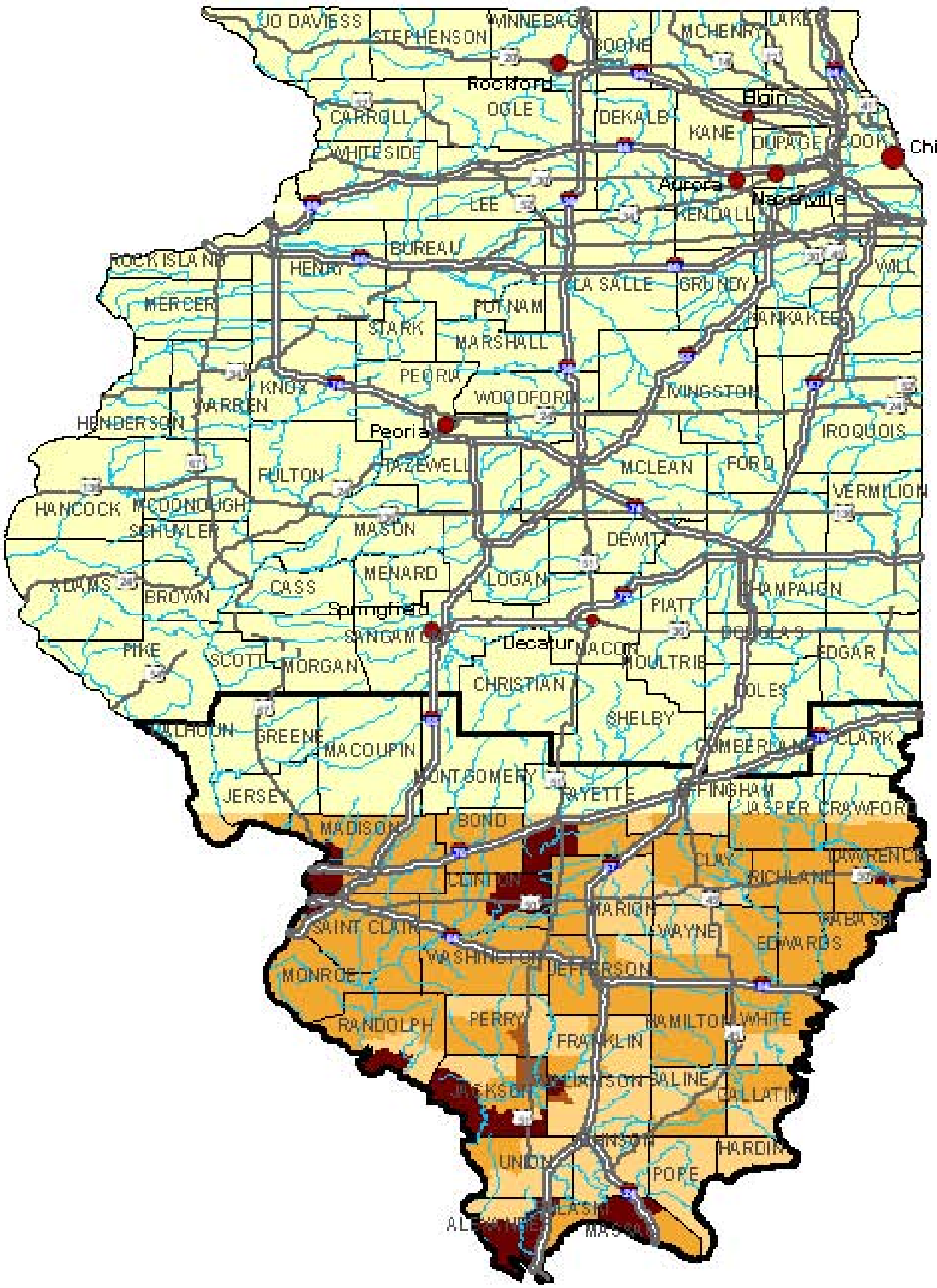
Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Minimum Susceptibility	Maximum Susceptibility
Alexander	Unknown	Very High
Bond	Unknown	Low
Calhoun	Unknown	None
Clark	Unknown	Unknown
Clay	None	Low
Clinton	Low	Very High
Crawford	Unknown	Low
Edwards	Low	Low
Effingham	Unknown	Low
Fayette	Unknown	Very High
Franklin	None	Low
Gallatin	Unknown	Low
Greene	Unknown	Unknown
Hamilton	Low	Low
Hardin	Unknown	None
Jackson	Unknown	Very High
Jasper	Unknown	Low
Jefferson	None	Low
Jersey	Unknown	Low
Johnson	None	None
Lawrence	Unknown	Very High
Macoupin	Unknown	None
Madison	Unknown	Very High
Marion	None	Very High
Massac	Unknown	Very High
Monroe	Unknown	Low
Montgomery	Unknown	None
Perry	None	Moderate
Pope	Unknown	None
Pulaski	Unknown	Very High
Randolph	Unknown	Very High
Richland	None	Low
Saint Clair	Low	Very High
Saline	None	Low
Union	Unknown	Low
Wabash	Unknown	Very High
Washington	Low	Low
Wayne	None	Low
White	Unknown	Low
Williamson	None	Very High

Legend

Liquefaction Susceptibility

- Unknown
- None
- Low
- Moderate
- Very High
- Rivers
- Critical Counties
- Interstates
- US Routes

Major Cities

- 80,000 - 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000

0 15 30 60 90
Miles

Mid-America Earthquake Center

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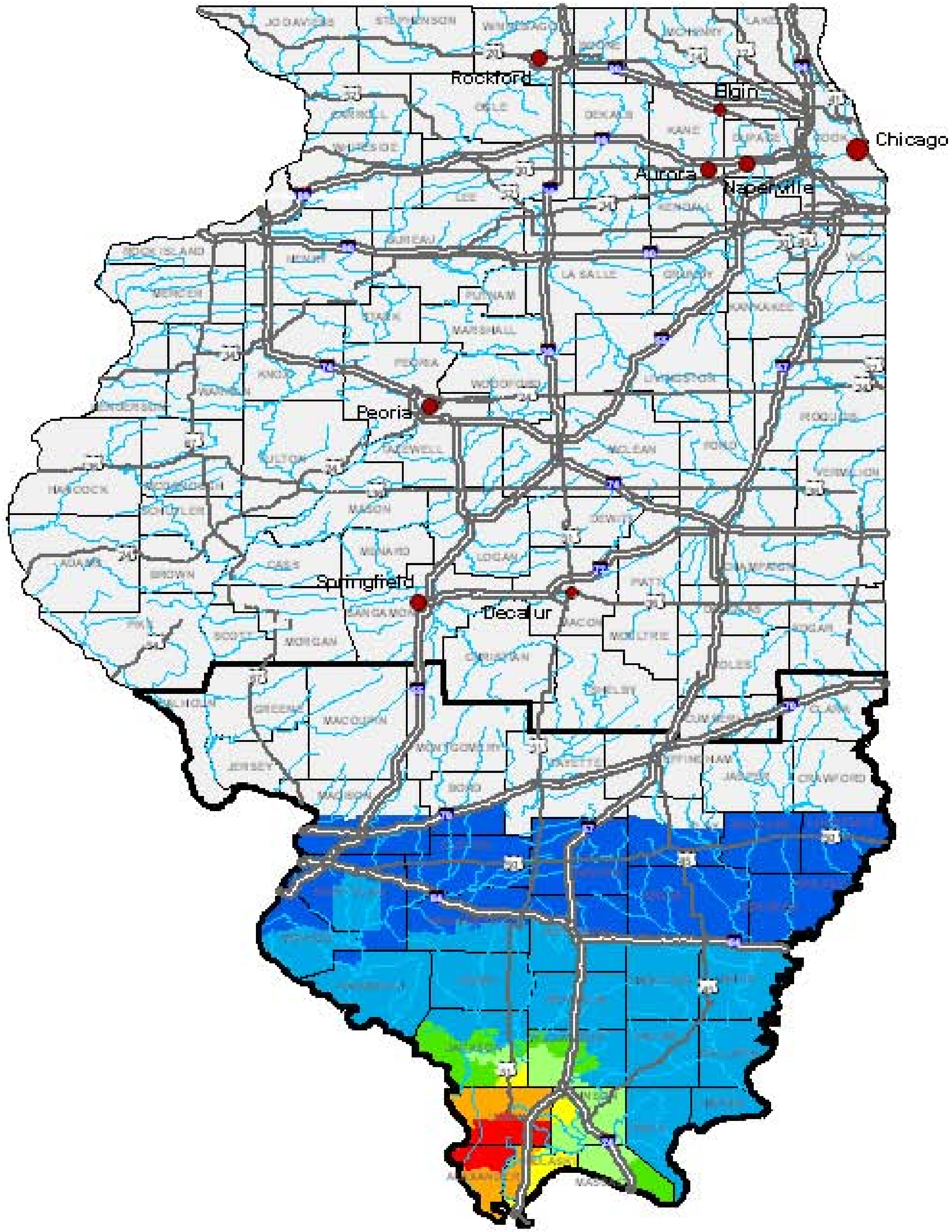
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Max. MMI
Alexander	XII
Bond	VI
Calhoun	< VI
Clark	< VI
Clay	VI
Clinton	VI
Crawford	< VI
Edwards	VII
Effingham	< VI
Fayette	< VI
Franklin	VII
Gallatin	VII
Greene	< VI
Hamilton	VII
Hardin	VII
Jackson	X
Jasper	< VI
Jefferson	VII
Jersey	< VI
Johnson	X
Lawrence	VI
Macoupin	< VI
Madison	VI
Marion	VI
Massac	IX
Monroe	VII
Montgomery	< VI
Perry	VII
Pope	VII
Pulaski	XI
Randolph	VII
Richland	VI
Saint Clair	VII
Saline	VII
Union	XII
Wabash	VI
Washington	VII
Wayne	VI
White	VII
Williamson	IX

Legend

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities

- 80,000- 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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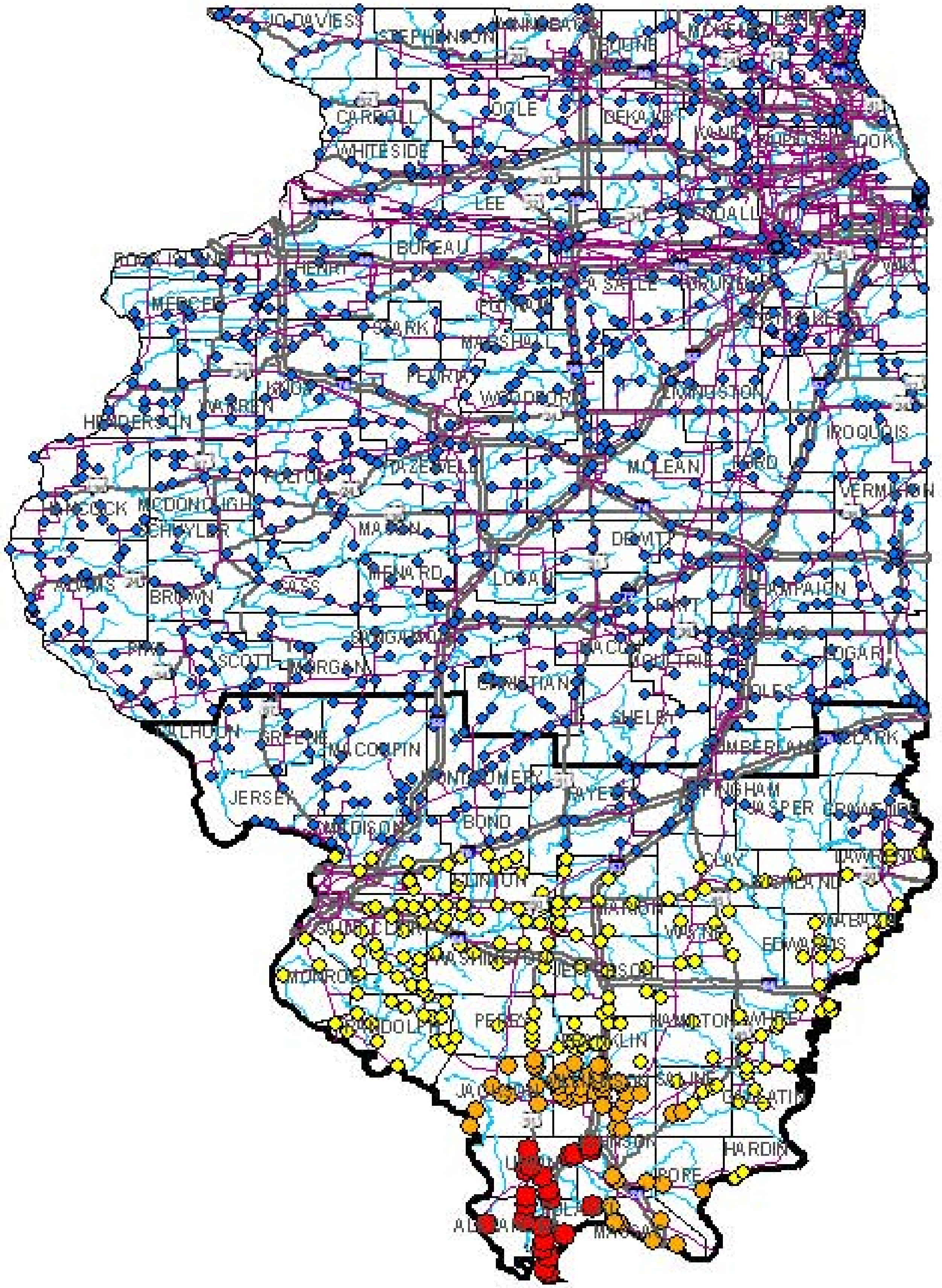
Natural Gas Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois
Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	5	5	1
Bond	10	0	0
Calhoun	2	0	0
Clark	7	0	0
Clay	5	0	0
Clinton	14	0	0
Crawford	12	0	0
Edwards	4	0	0
Effingham	13	0	0
Fayette	13	0	0
Franklin	19	5	0
Gallatin	7	0	0
Greene	13	0	0
Hamilton	4	0	0
Hardin	2	0	0
Jackson	12	12	0
Jasper	2	0	0
Jefferson	10	0	0
Jersey	7	0	0
Johnson	5	5	0
Lawrence	6	0	0
Macoupin	21	0	0
Madison	20	0	0
Marion	13	0	0
Massac	8	8	0
Monroe	4	0	0
Montgomery	20	0	0
Perry	6	0	0
Pope	2	2	0
Pulaski	7	7	0
Randolph	18	0	0
Richland	2	0	0
Saint Clair	21	0	0
Saline	7	2	0
Union	8	8	3
Wabash	4	0	0
Washington	10	0	0
Wayne	7	0	0
White	13	0	0
Williamson	25	25	0

Legend

Natural Gas Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Natural Gas Transmission Lines
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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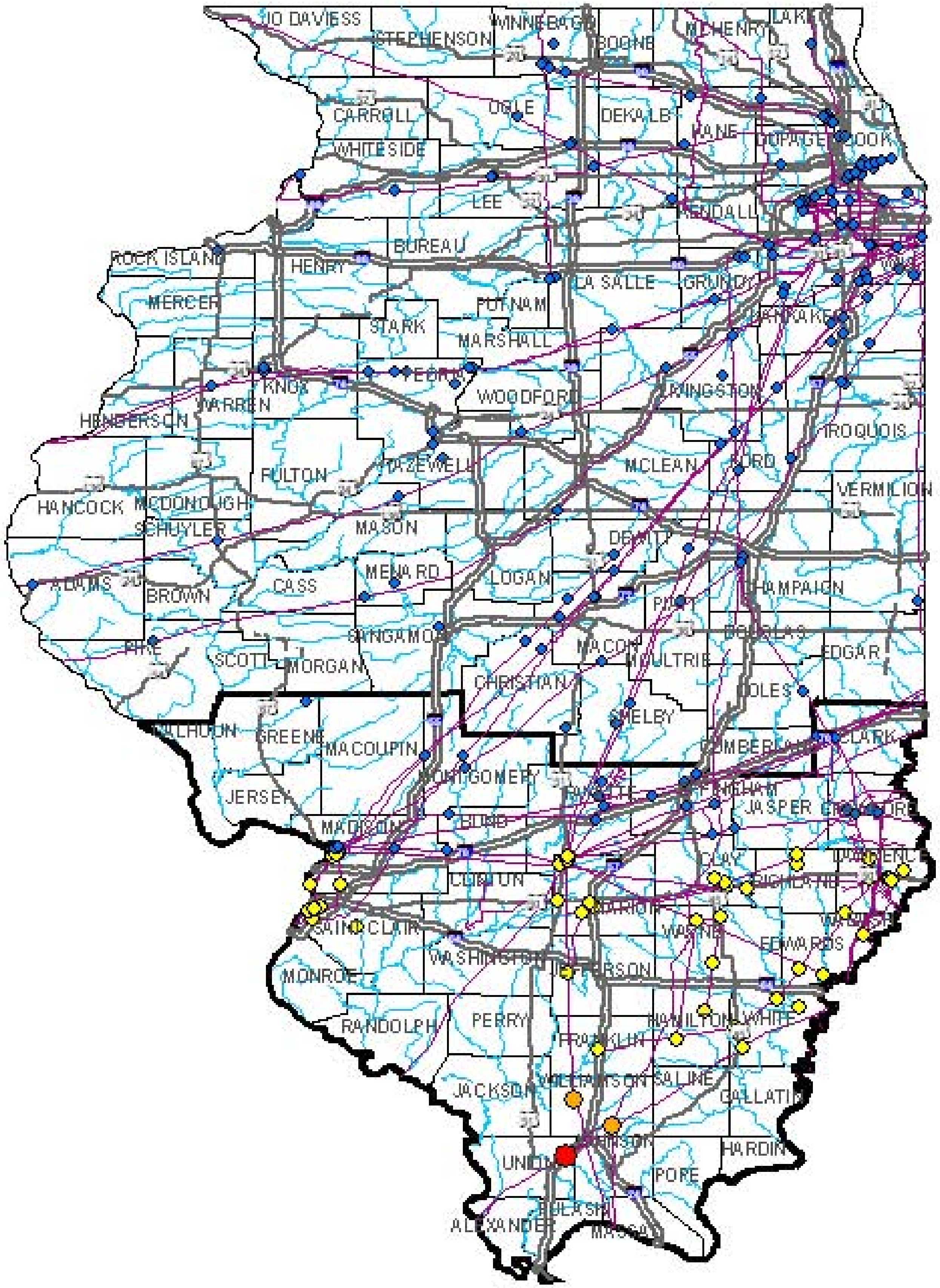
Oil Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Bond	2	0	0
Clark	2	0	0
Clay	6	0	0
Crawford	4	0	0
Edwards	3	0	0
Effingham	5	0	0
Fayette	4	0	0
Franklin	1	0	0
Greene	1	0	0
Hamilton	2	0	0
Jasper	1	0	0
Jefferson	1	0	0
Lawrence	7	0	0
Madison	31	0	0
Marion	12	0	0
Montgomery	3	0	0
Richland	2	0	0
Saint Clair	7	0	0
Union	1	1	0
Wabash	3	0	0
Wayne	4	0	0
White	5	0	0
Williamson	2	2	0
Alexander	0	0	0
Calhoun	0	0	0
Clinton	0	0	0
Gallatin	0	0	0
Hardin	0	0	0
Jackson	0	0	0
Jersey	0	0	0
Johnson	0	0	0
Macoupin	0	0	0
Massac	0	0	0
Monroe	0	0	0
Perry	0	0	0
Pope	0	0	0
Pulaski	0	0	0
Randolph	0	0	0
Saline	0	0	0
Washington	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Oil Transmission Lines
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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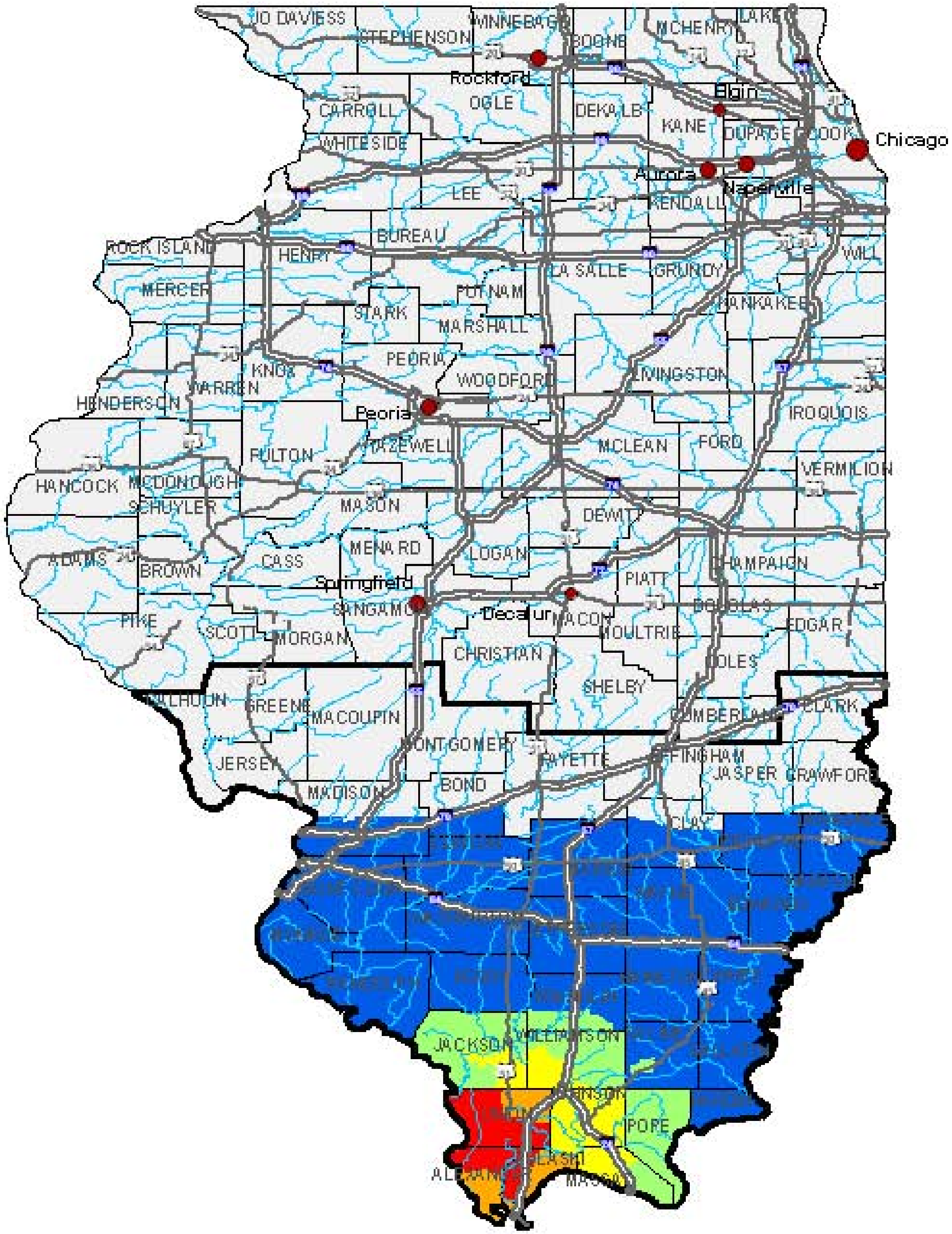
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Min. PGA	Max. PGA
Alexander	0.75	1.25
Bond	0.05	0.15
Calhoun	0.05	0.05
Clark	0.05	0.05
Clay	0.05	0.15
Clinton	0.15	0.15
Crawford	0.05	0.05
Edwards	0.15	0.25
Effingham	0.05	0.05
Fayette	0.05	0.05
Franklin	0.25	0.34
Gallatin	0.25	0.25
Greene	0.05	0.05
Hamilton	0.25	0.25
Hardin	0.25	0.25
Jackson	0.34	0.75
Jasper	0.05	0.05
Jefferson	0.15	0.25
Jersey	0.05	0.05
Johnson	0.64	0.75
Lawrence	0.15	0.15
Macoupin	0.05	0.05
Madison	0.05	0.15
Marion	0.05	0.15
Massac	0.44	0.64
Monroe	0.15	0.25
Montgomery	0.05	0.05
Perry	0.25	0.25
Pope	0.34	0.34
Pulaski	0.85	1.04
Randolph	0.15	0.25
Richland	0.15	0.15
Saint Clair	0.15	0.25
Saline	0.25	0.34
Union	0.94	1.38
Wabash	0.15	0.15
Washington	0.15	0.25
Wayne	0.15	0.15
White	0.25	0.25
Williamson	0.34	0.64

Legend

PGA (g)
- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.38
- Rivers
- Critical Counties
- Interstates
- US Routes

Major Cities
- 80,000- 100,000
- 100,001 - 200,000
- 200,001 - 2,750,000

0 15 30 60 90
Miles

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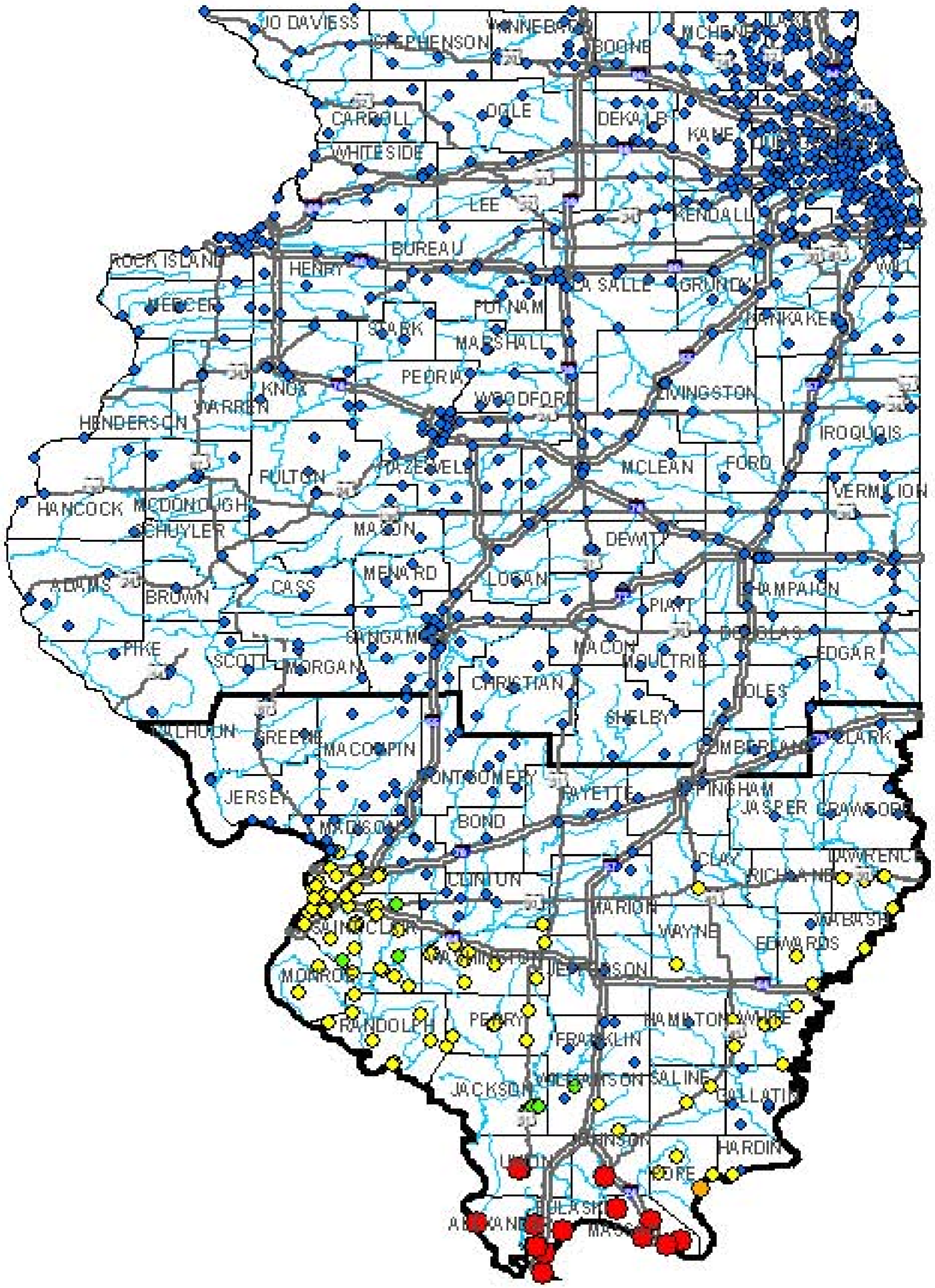
Theresa Jefferson, Principal Investigator

Police Station Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	2	2	2
Bond	3	0	0
Calhoun	2	0	0
Clark	5	0	0
Clay	2	0	0
Clinton	8	0	0
Crawford	5	0	0
Edwards	3	0	0
Effingham	5	0	0
Fayette	6	0	0
Franklin	7	0	0
Gallatin	6	0	0
Greene	5	0	0
Hamilton	1	0	0
Hardin	3	0	0
Jackson	6	0	0
Jasper	2	0	0
Jefferson	2	0	0
Jersey	4	0	0
Johnson	1	1	0
Lawrence	5	0	0
Macoupin	14	0	0
Madison	39	0	0
Marion	6	0	0
Massac	8	8	4
Monroe	6	0	0
Montgomery	11	0	0
Perry	7	0	0
Pope	4	1	0
Pulaski	6	6	6
Randolph	9	0	0
Richland	2	0	0
Saint Clair	36	0	0
Saline	4	0	0
Union	3	3	3
Wabash	2	0	0
Washington	11	0	0
Wayne	4	0	0
White	7	0	0
Williamson	5	0	0

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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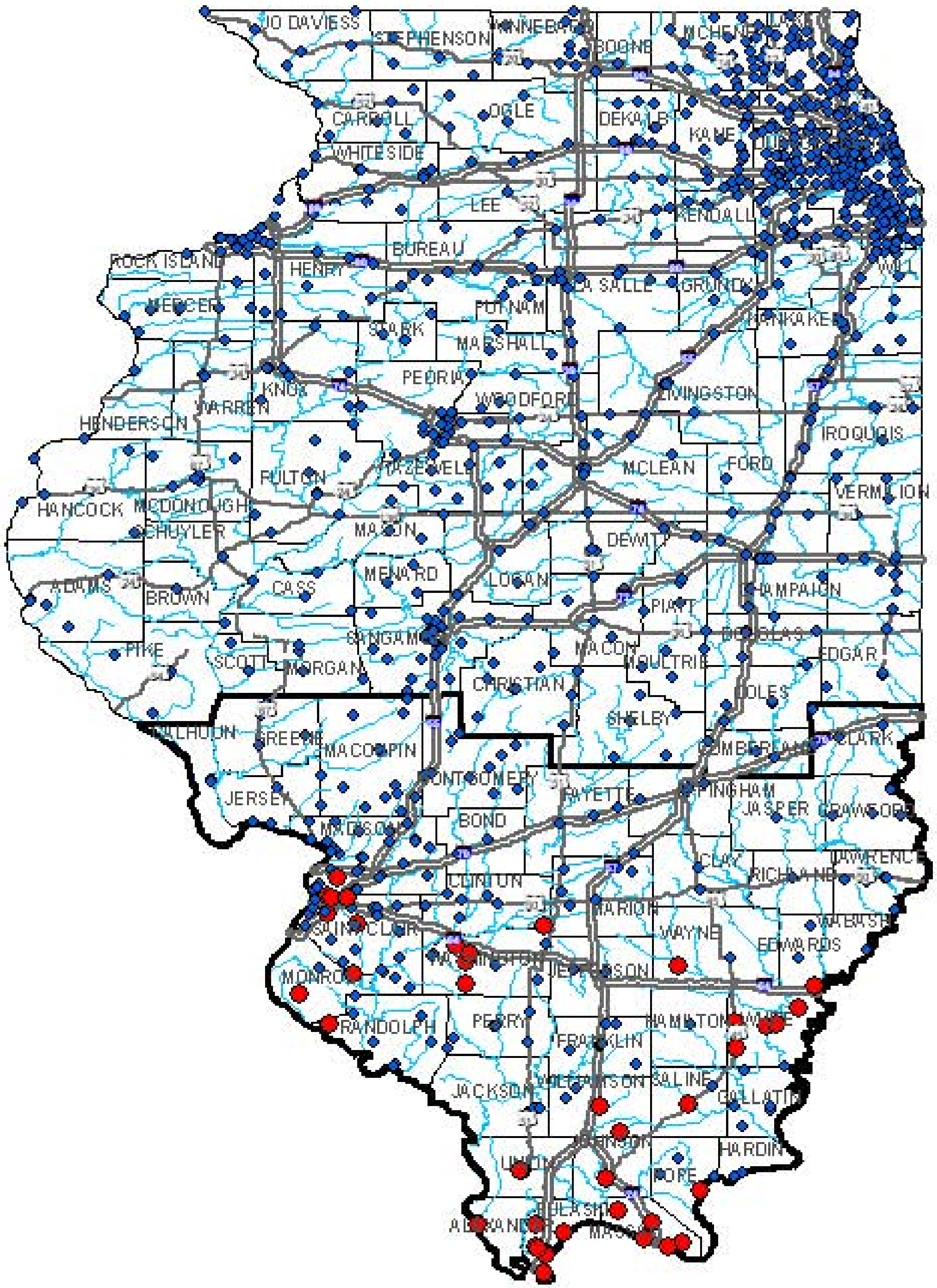
Police Station Functionality - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Alexander	0	2
Bond	3	3
Calhoun	2	2
Clark	5	5
Clay	2	2
Clinton	7	8
Crawford	5	5
Edwards	3	3
Effingham	5	5
Fayette	6	6
Franklin	7	7
Gallatin	6	6
Greene	5	5
Hamilton	1	1
Hardin	3	3
Jackson	6	6
Jasper	2	2
Jefferson	2	2
Jersey	4	4
Johnson	0	1
Lawrence	5	5
Macoupin	14	14
Madison	37	39
Marion	6	6
Massac	0	8
Monroe	4	6
Montgomery	11	11
Perry	7	7
Pope	3	4
Pulaski	0	6
Randolph	8	9
Richland	2	2
Saint Clair	31	36
Saline	3	4
Union	0	3
Wabash	2	2
Washington	7	11
Wayne	3	4
White	0	7
Williamson	3	5

Legend

- Rivers
- Critical Counties
- Interstates
- US Routes

Police Station Functionality

Day 1

- Not Functional
- Functional

0 15 30 60 90

Miles

Mid-America Earthquake Center

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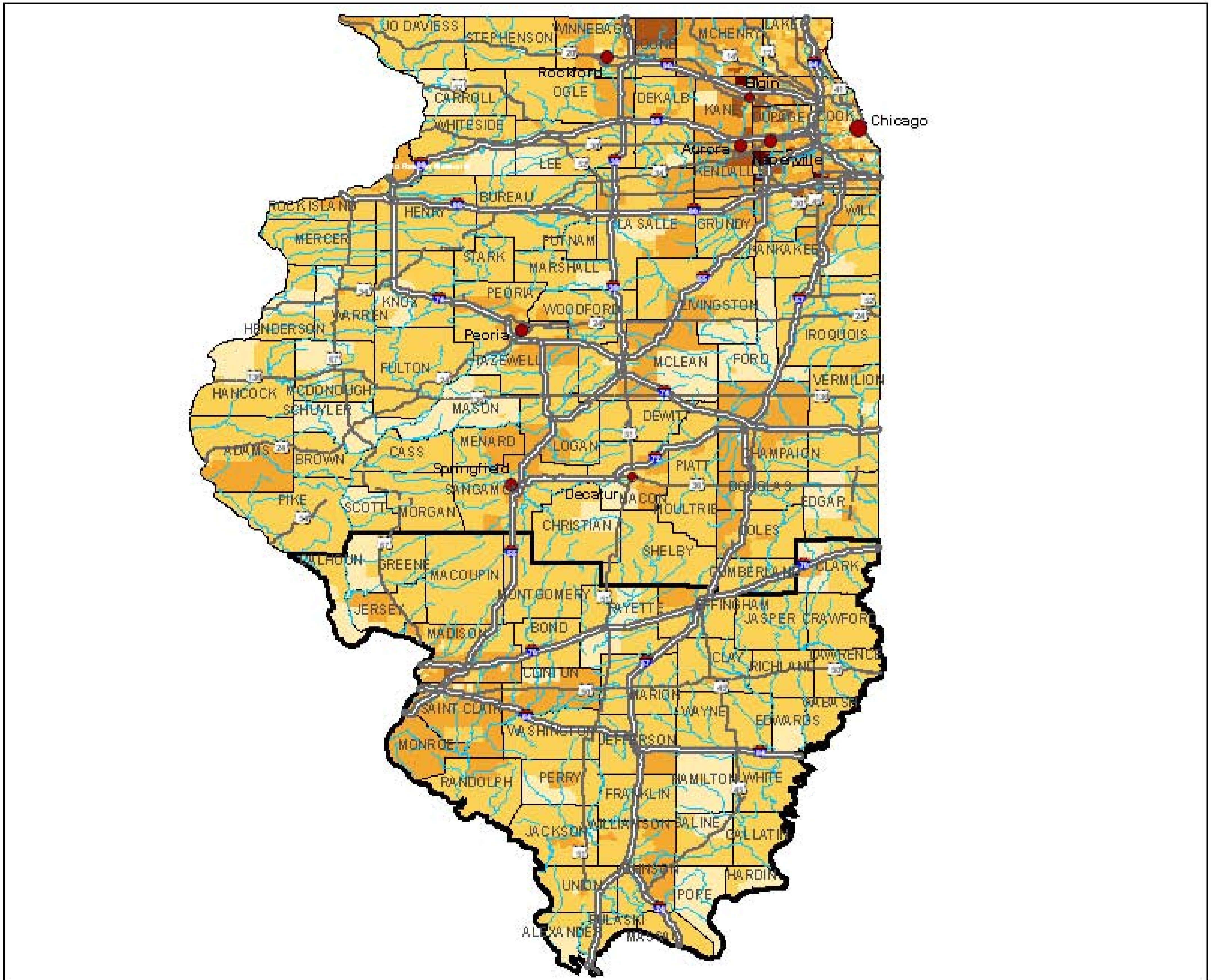
Total Population - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Population
Alexander	13,457
Bond	17,633
Calhoun	5,084
Clark	19,913
Clay	17,542
Clinton	45,875
Crawford	20,452
Edwards	14,307
Effingham	36,913
Fayette	30,812
Franklin	41,719
Gallatin	6,445
Greene	22,811
Hamilton	8,621
Hardin	4,800
Jackson	63,423
Jasper	10,117
Jefferson	40,045
Jersey	21,668
Johnson	12,878
Lawrence	15,452
Macoupin	49,019
Madison	258,941
Marion	43,982
Massac	15,161
Monroe	27,619
Montgomery	37,524
Perry	29,415
Pope	4,413
Pulaski	9,682
Randolph	42,816
Richland	16,149
Saint Clair	256,082
Saline	26,733
Union	21,516
Wabash	15,185
Washington	15,148
Wayne	17,151
White	15,371
Williamson	61,296

Legend

Total Population

HAZUS (2000)

- 0 - 2,500
- 2,501 - 5,000
- 5,001 - 10,000
- 10,001 - 15,000
- 15,001 - 34,055

Rivers
Critical Counties
Interstates
US Routes

Major Cities

80,000- 100,000
100,001 - 200,000
200,001 - 2,750,000

0 15 30 60 90
Miles

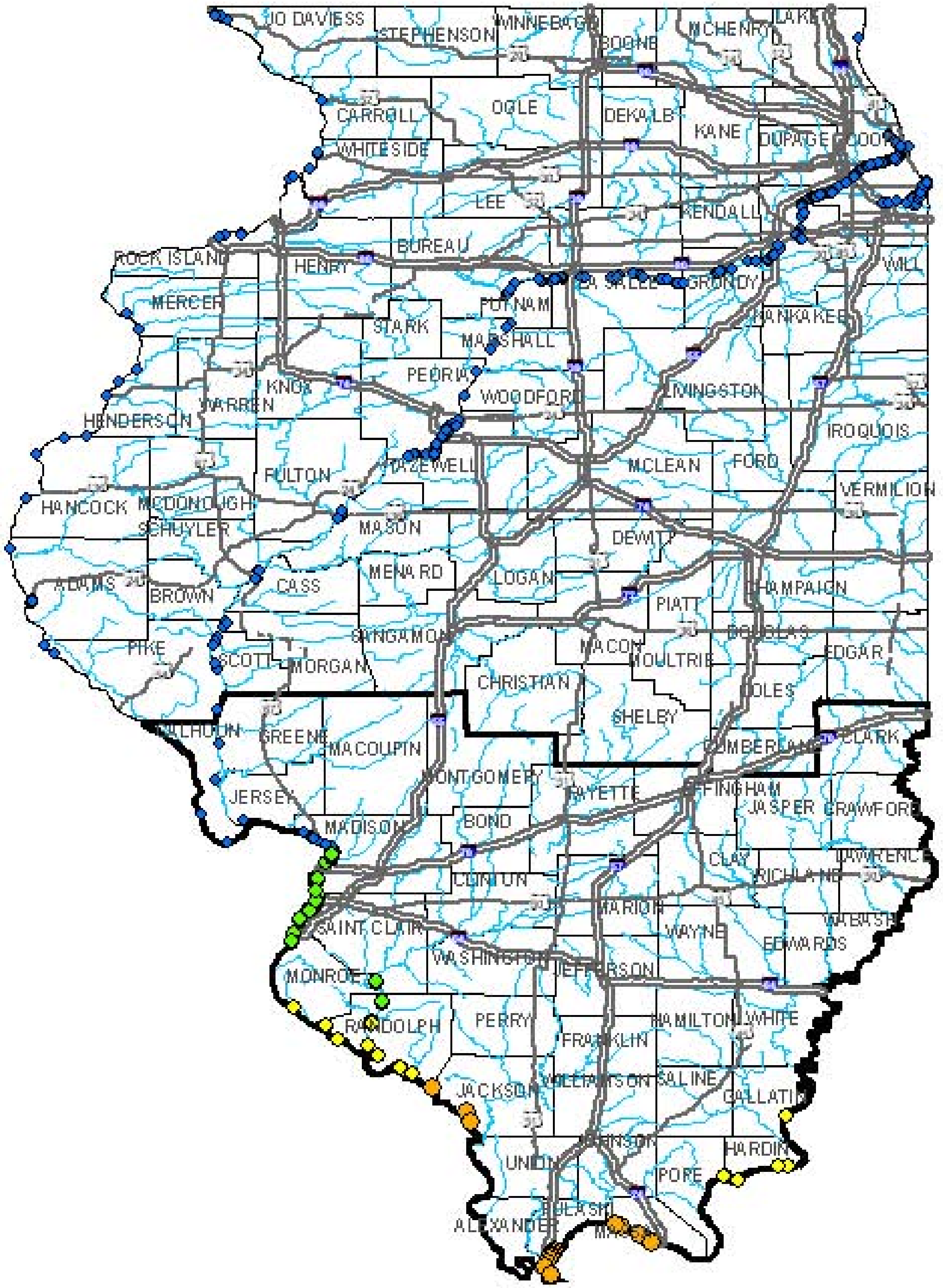
Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Port Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	6	6	0
Calhoun	5	0	0
Gallatin	3	0	0
Greene	1	0	0
Hardin	5	0	0
Jackson	3	3	0
Jersey	1	0	0
Madison	48	0	0
Massac	5	5	0
Monroe	7	0	0
Pulaski	5	5	0
Randolph	15	0	0
Saint Clair	22	0	0
Bond	0	0	0
Clark	0	0	0
Clay	0	0	0
Clinton	0	0	0
Crawford	0	0	0
Edwards	0	0	0
Effingham	0	0	0
Fayette	0	0	0
Franklin	0	0	0
Hamilton	0	0	0
Jasper	0	0	0
Jefferson	0	0	0
Johnson	0	0	0
Lawrence	0	0	0
Macoupin	0	0	0
Marion	0	0	0
Montgomery	0	0	0
Perry	0	0	0
Pope	0	0	0
Richland	0	0	0
Saline	0	0	0
Union	0	0	0
Wabash	0	0	0
Washington	0	0	0
Wayne	0	0	0
White	0	0	0
Williamson	0	0	0

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

Mid-America Earthquake Center

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Potable Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008

State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Bond	1	0	0
Calhoun	3	0	0
Clark	3	0	0
Clay	1	0	0
Clinton	2	0	0
Edwards	1	0	0
Effingham	3	0	0
Fayette	2	0	0
Franklin	1	0	0
Gallatin	3	0	0
Greene	4	0	0
Jackson	2	2	0
Jasper	1	0	0
Johnson	3	3	0
Lawrence	2	0	0
Macoupin	4	0	0
Madison	8	0	0
Marion	2	0	0
Monroe	1	0	0
Montgomery	4	0	0
Pulaski	1	1	0
Randolph	4	0	0
Saint Clair	6	0	0
Union	2	2	1
Wabash	1	0	0
Washington	2	0	0
Wayne	3	0	0
White	1	0	0
Williamson	3	3	0
Alexander	0	0	0
Crawford	0	0	0
Hamilton	0	0	0
Hardin	0	0	0
Jefferson	0	0	0
Jersey	0	0	0
Massac	0	0	0
Perry	0	0	0
Pope	0	0	0
Richland	0	0	0
Saline	0	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Potable Water Distribution Lines

No. of Leaks

- 1 - 10
- 10 - 50
- 50 - 100
- 100 - 300
- 300 - 716

- US Routes
- Interstates
- Critical Counties
- Rivers

0 15 30 60 90
Miles

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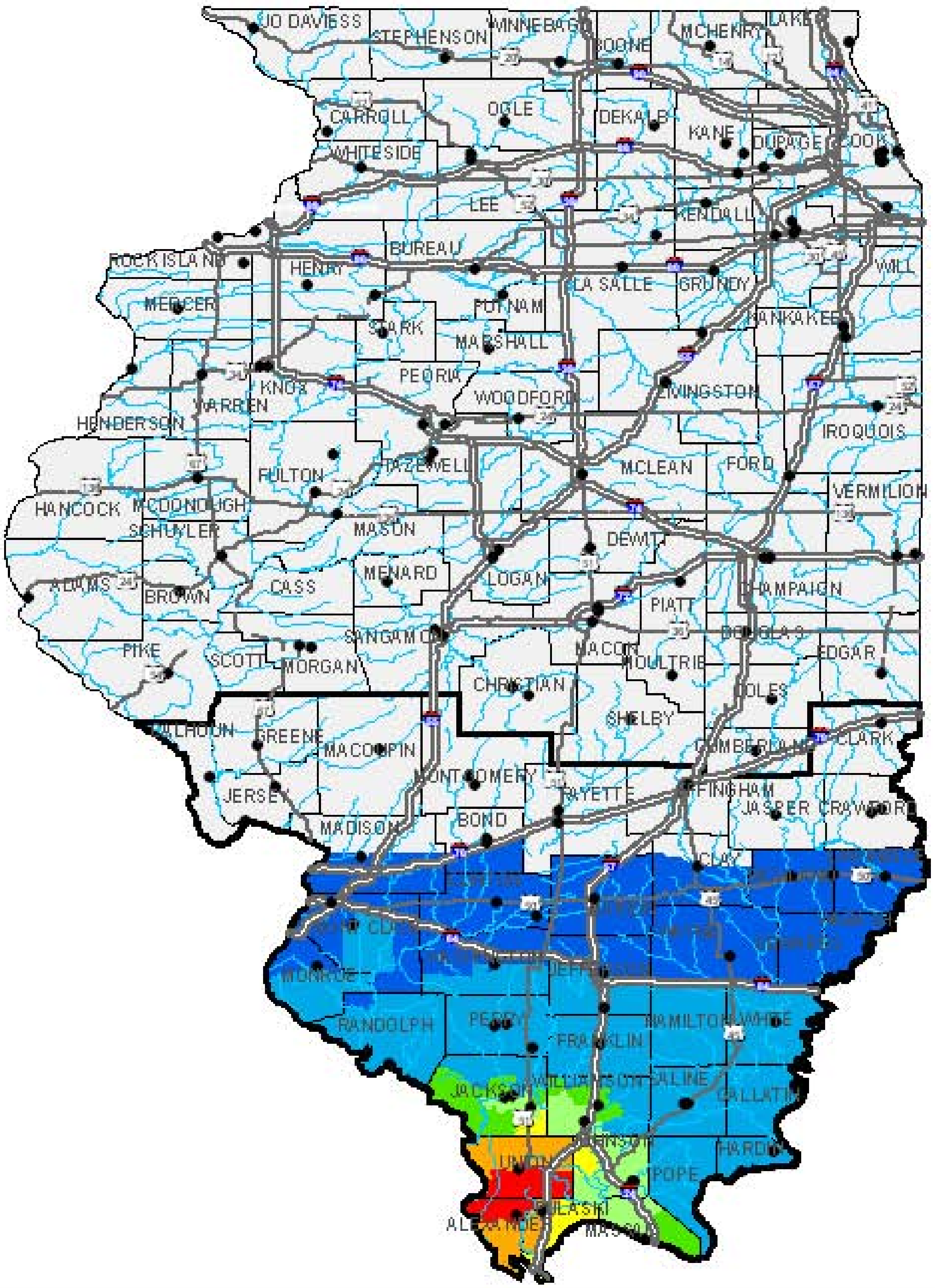
Prisons - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Facilities
Alexander	1
Bond	2
Calhoun	1
Clark	1
Clay	1
Clinton	2
Crawford	2
Edwards	0
Effingham	1
Fayette	2
Franklin	1
Gallatin	0
Greene	1
Hamilton	0
Hardin	2
Jackson	3
Jasper	1
Jefferson	2
Jersey	2
Johnson	2
Lawrence	1
Macoupin	1
Madison	1
Marion	1
Massac	1
Monroe	1
Montgomery	2
Perry	3
Pope	0
Pulaski	1
Randolph	2
Richland	2
Saint Clair	2
Saline	2
Union	1
Wabash	1
Washington	1
Wayne	1
White	1
Williamson	2

Legend

- Prisons

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

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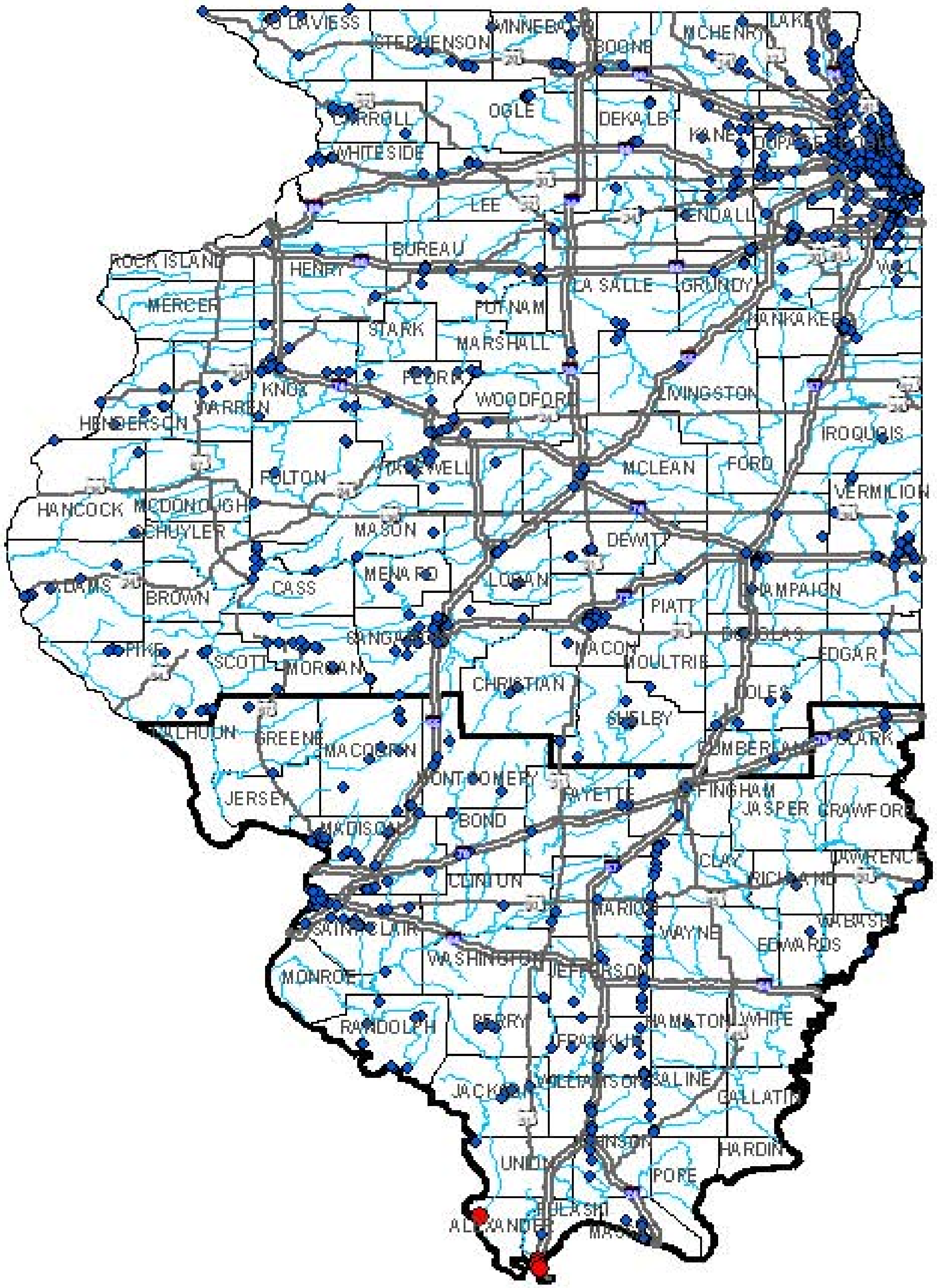
Railway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Alexander	0	6
Bond	3	3
Clark	5	5
Clay	8	8
Clinton	1	1
Edwards	1	1
Effingham	6	6
Fayette	3	3
Franklin	16	16
Greene	2	2
Hamilton	1	1
Jackson	7	7
Jefferson	14	14
Johnson	4	4
Lawrence	1	1
Macoupin	13	13
Madison	35	35
Marion	7	7
Massac	7	7
Montgomery	5	5
Perry	5	5
Pulaski	1	1
Randolph	9	9
Richland	2	2
Saint Clair	35	35
Saline	3	3
Wabash	1	1
Williamson	7	7
Calhoun	0	0
Crawford	0	0
Gallatin	0	0
Hardin	0	0
Jasper	0	0
Jersey	0	0
Monroe	0	0
Pope	0	0
Union	0	0
Washington	0	0
Wayne	0	0
White	0	0

Legend

Railway Bridge Functionality

Day 1

- Not Functional
- Functional
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

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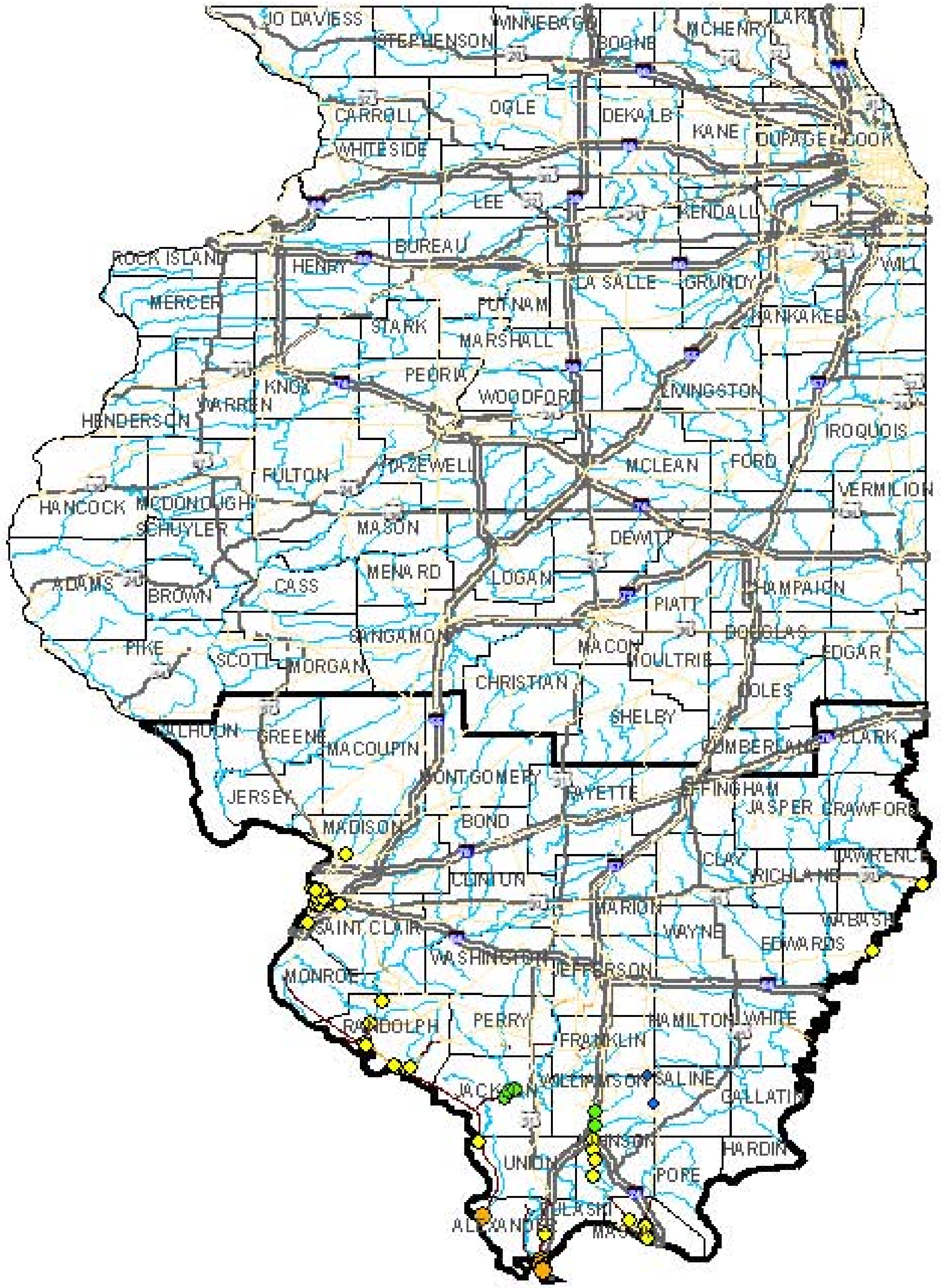
Railway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	6	6	0
Bond	3	0	0
Clark	5	0	0
Clay	8	0	0
Clinton	1	0	0
Edwards	1	0	0
Effingham	6	0	0
Fayette	3	0	0
Franklin	16	0	0
Greene	2	0	0
Hamilton	1	0	0
Jackson	7	0	0
Jefferson	14	0	0
Johnson	4	0	0
Lawrence	1	0	0
Macoupin	13	0	0
Madison	35	0	0
Marion	7	0	0
Massac	7	0	0
Montgomery	5	0	0
Perry	5	0	0
Pulaski	1	0	0
Randolph	9	0	0
Richland	2	0	0
Saint Clair	35	0	0
Saline	3	0	0
Wabash	1	0	0
Williamson	7	0	0
Calhoun	0	0	0
Crawford	0	0	0
Gallatin	0	0	0
Hardin	0	0	0
Jasper	0	0	0
Jersey	0	0	0
Monroe	0	0	0
Pope	0	0	0
Union	0	0	0
Washington	0	0	0
Wayne	0	0	0
White	0	0	0

Legend

Railway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

US Routes

Interstates

Critical Counties

Rivers

Railway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood

0 15 30 60 90

Miles

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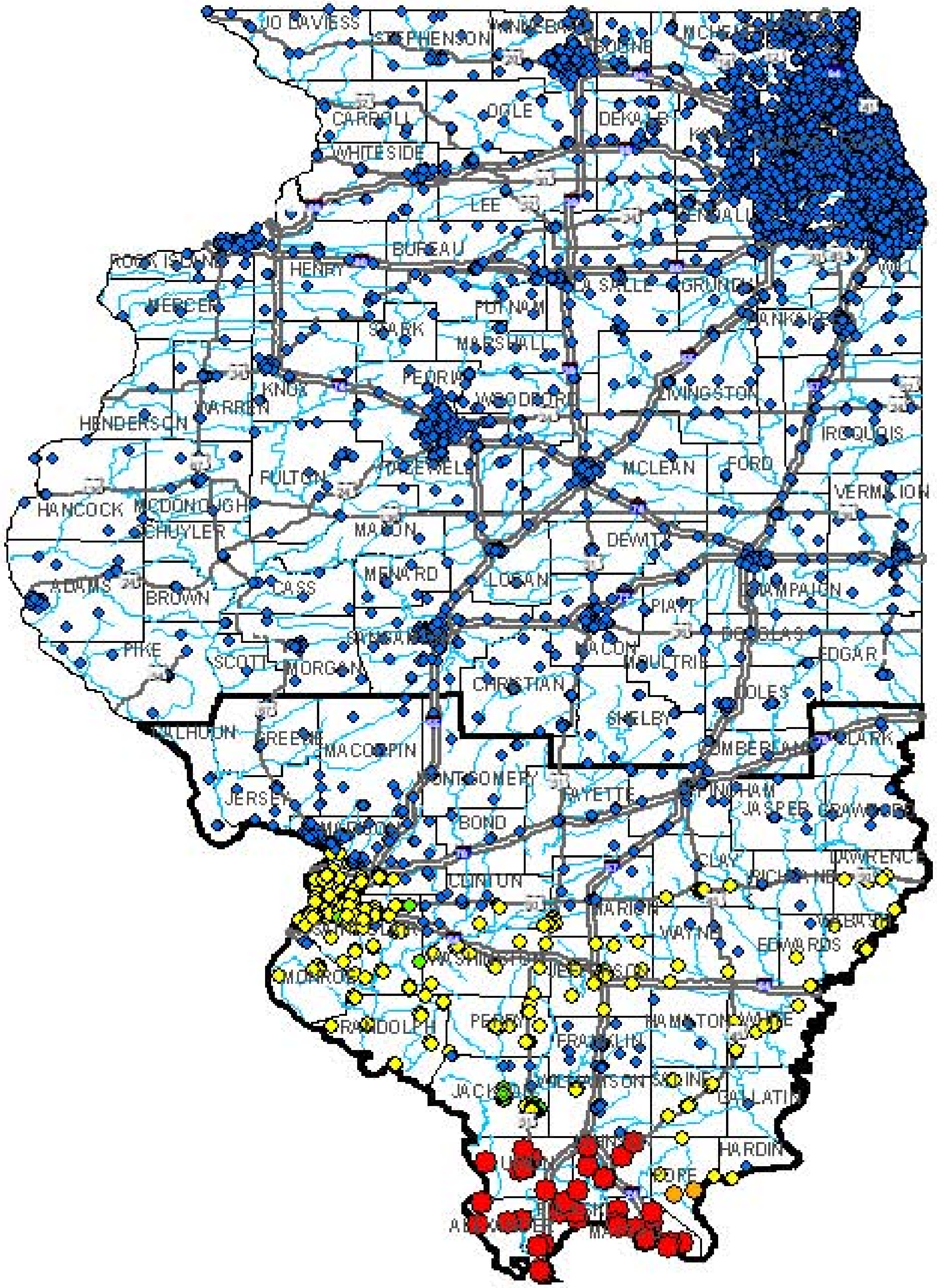
School Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	15	15	15
Bond	8	0	0
Calhoun	7	0	0
Clark	9	0	0
Clay	11	0	0
Clinton	26	0	0
Crawford	12	0	0
Edwards	3	0	0
Effingham	25	0	0
Fayette	13	0	0
Franklin	28	0	0
Gallatin	1	0	0
Greene	9	0	0
Hamilton	6	0	0
Hardin	5	0	0
Jackson	80	0	0
Jasper	7	0	0
Jefferson	19	0	0
Jersey	11	0	0
Johnson	8	8	6
Lawrence	8	0	0
Macoupin	32	0	0
Madison	320	0	0
Marion	30	0	0
Massac	33	33	19
Monroe	25	0	0
Montgomery	20	0	0
Perry	15	0	0
Pope	31	6	0
Pulaski	9	9	9
Randolph	22	0	0
Richland	7	0	0
Saint Clair	212	0	0
Saline	17	0	0
Union	12	12	11
Wabash	8	0	0
Washington	22	0	0
Wayne	13	0	0
White	12	0	0
Williamson	16	0	0

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

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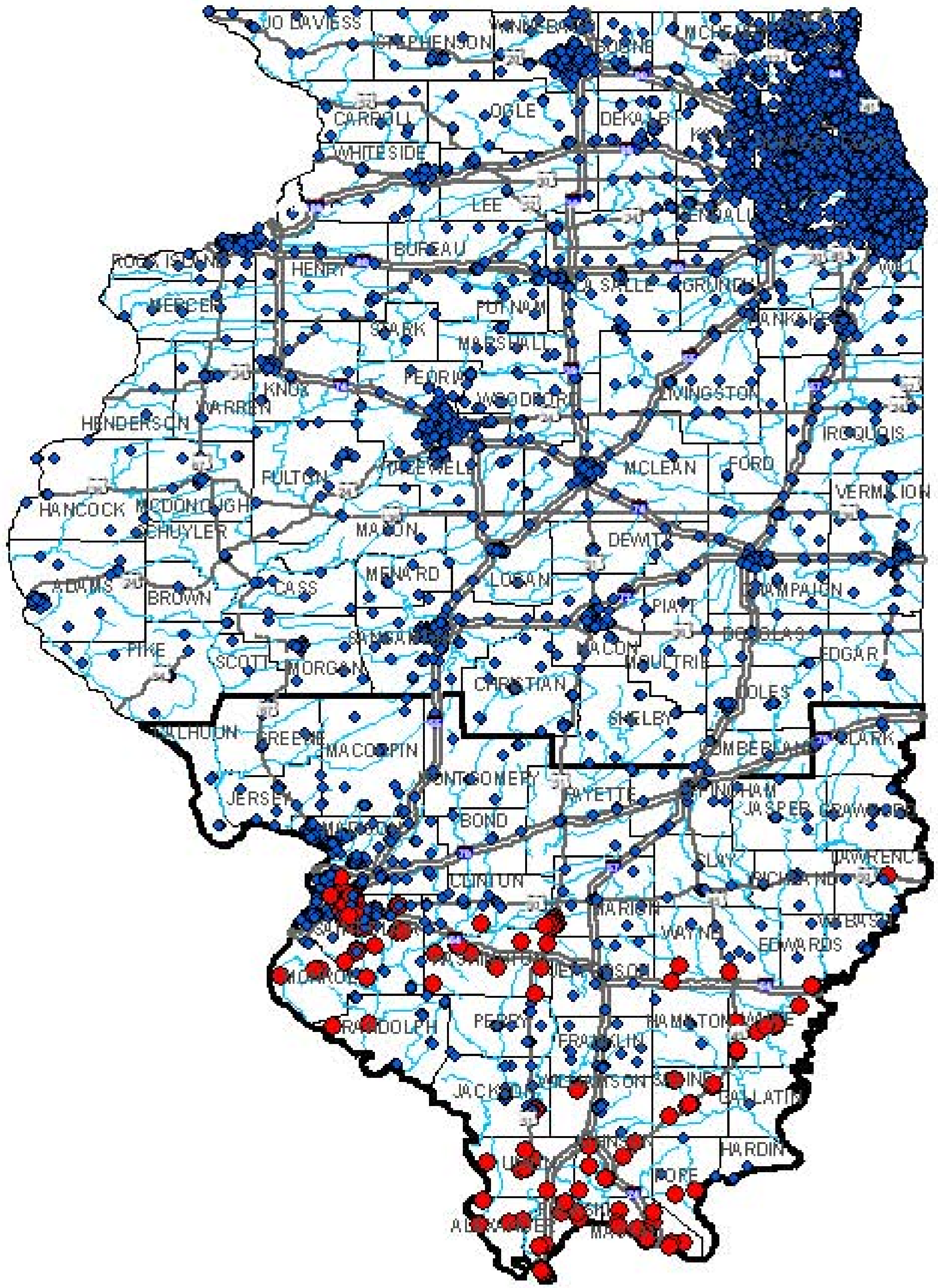
School Functionality - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	No. of Functional Facilities	Total No. of Facilities
Alexander	0	15
Bond	8	8
Calhoun	7	7
Clark	9	9
Clay	11	11
Clinton	21	26
Crawford	12	12
Edwards	3	3
Effingham	25	25
Fayette	13	13
Franklin	28	28
Gallatin	1	1
Greene	9	9
Hamilton	6	6
Hardin	5	5
Jackson	79	80
Jasper	7	7
Jefferson	19	19
Jersey	11	11
Johnson	0	8
Lawrence	7	8
Macoupin	32	32
Madison	314	320
Marion	21	30
Massac	0	33
Monroe	11	25
Montgomery	20	20
Perry	15	15
Pope	25	31
Pulaski	0	9
Randolph	19	22
Richland	7	7
Saint Clair	134	212
Saline	0	17
Union	0	12
Wabash	8	8
Washington	0	22
Wayne	9	13
White	0	12
Williamson	13	16

Legend

School Functionality

Day 1

- Not Functional
- Functional
- Rivers
- Critical Counties
- Interstates
- US Routes

0 15 30 60 90

Miles

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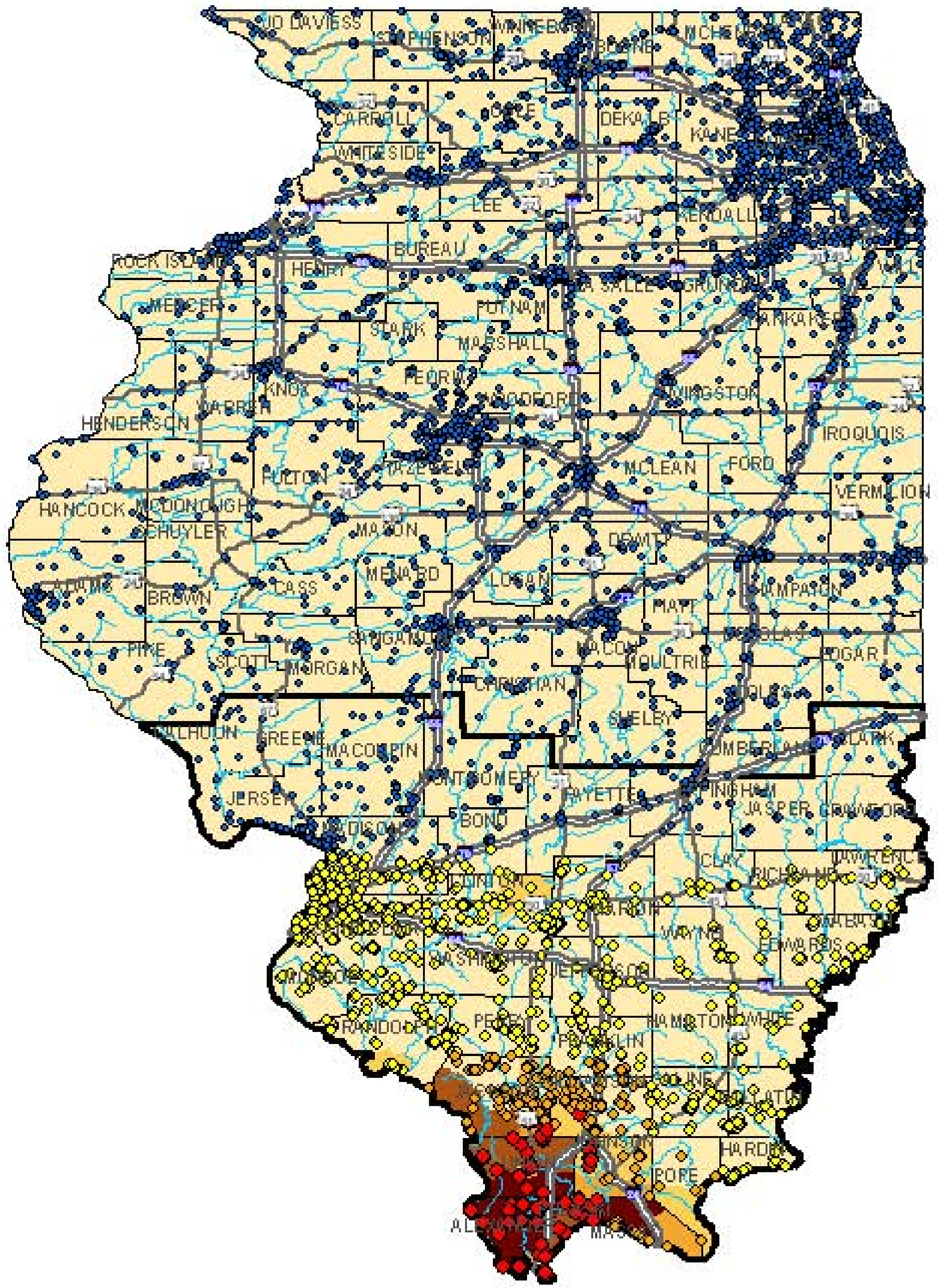
Waste Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

February 2008



State of Illinois Critical Counties (40)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alexander	22	22	0
Bond	24	0	0
Calhoun	5	0	0
Clark	34	0	0
Clay	20	0	0
Clinton	77	0	0
Crawford	31	0	0
Edwards	16	0	0
Effingham	67	0	0
Fayette	29	0	0
Franklin	59	22	0
Gallatin	67	0	0
Greene	30	0	0
Hamilton	7	0	0
Hardin	27	0	0
Jackson	104	104	0
Jasper	20	0	0
Jefferson	58	0	0
Jersey	27	0	0
Johnson	23	23	0
Lawrence	35	0	0
Macoupin	79	0	0
Madison	273	0	0
Marion	67	0	0
Massac	31	31	0
Monroe	43	0	0
Montgomery	87	0	0
Perry	73	0	0
Pope	14	14	0
Pulaski	28	28	0
Randolph	70	0	0
Richland	18	0	0
Saint Clair	243	0	0
Saline	84	0	0
Union	25	25	2
Wabash	22	0	0
Washington	43	0	0
Wayne	24	0	0
White	23	0	0
Williamson	104	104	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Waste Water Distribution Lines

No. of Leaks

- 0 - 10
- 10 - 50
- 50 - 100
- 100 - 250
- 250 - 570

- US Routes
- Interstates
- Critical Counties
- Rivers

0 15 30 60 90

Miles

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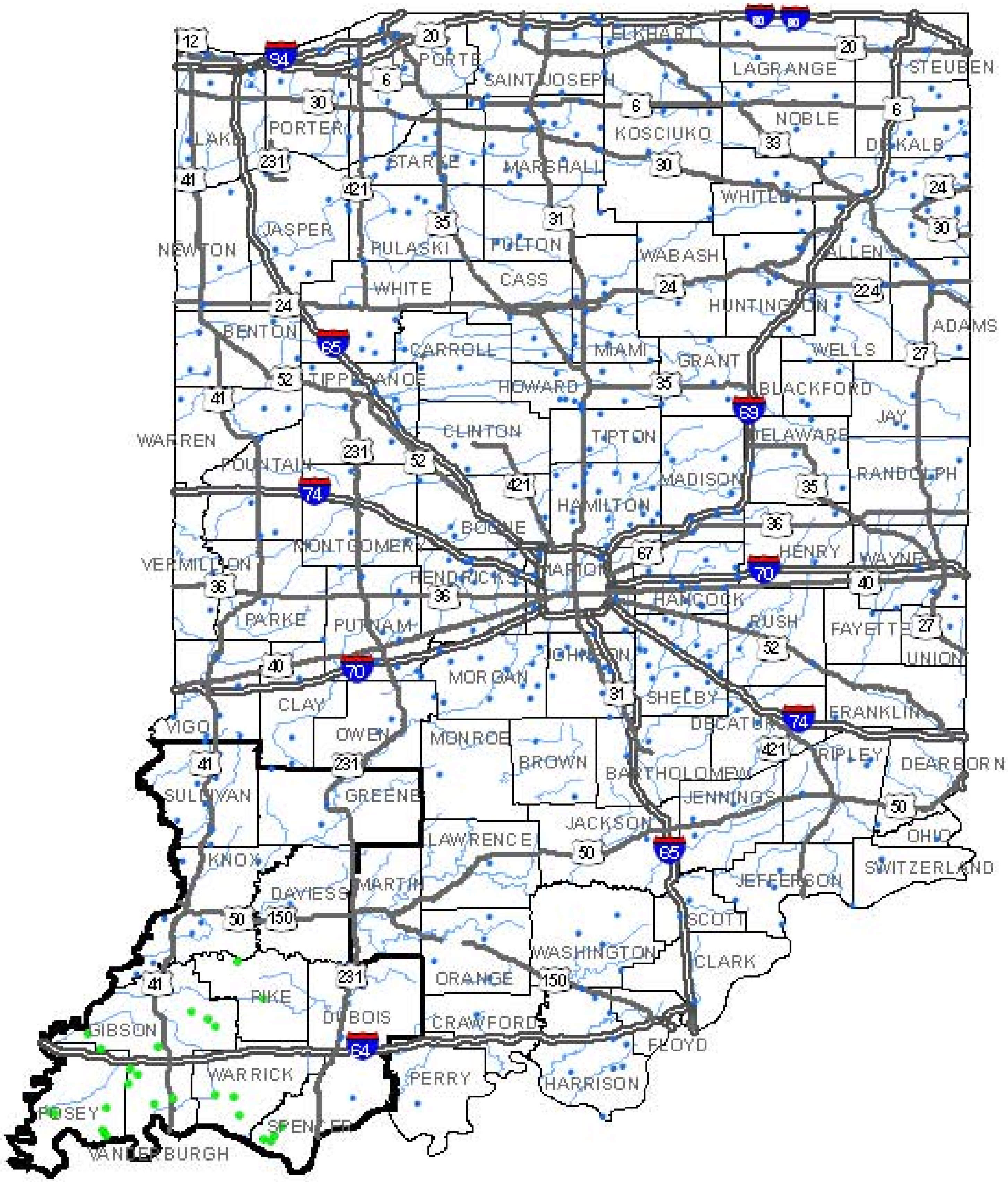
Airport Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	1	0	0
Dubois	2	0	0
Gibson	7	0	0
Greene	3	0	0
Knox	8	0	0
Pike	2	0	0
Posey	6	0	0
Spencer	5	0	0
Sullivan	7	0	0
Vanderburgh	5	0	0
Warrick	3	0	0

Legend

Airport Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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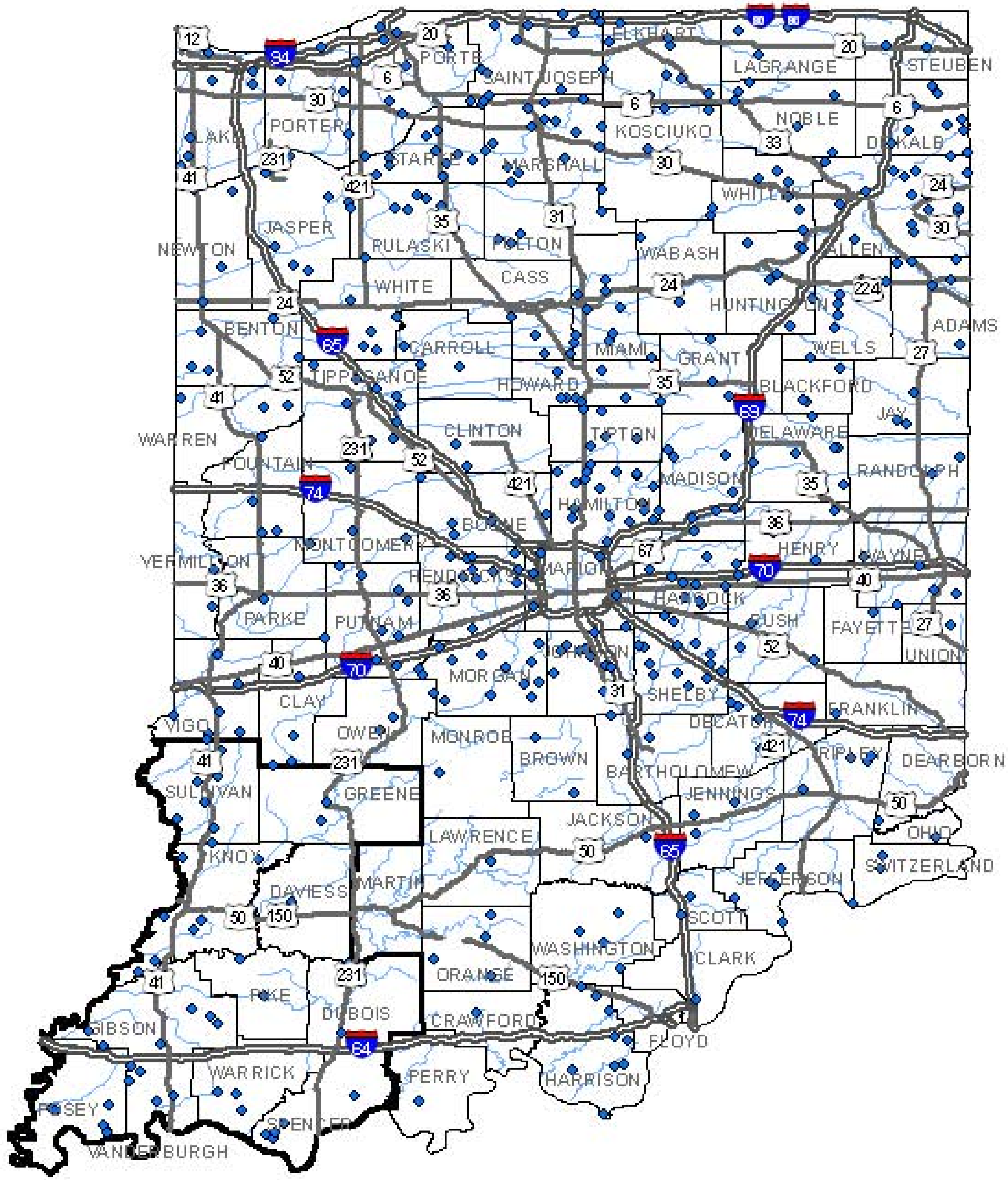
Airport Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	1	1
Dubois	2	2
Gibson	7	7
Greene	3	3
Knox	8	8
Pike	2	2
Posey	6	6
Spencer	5	5
Sullivan	7	7
Vanderburgh	5	5
Warrick	3	3

Legend

Airport Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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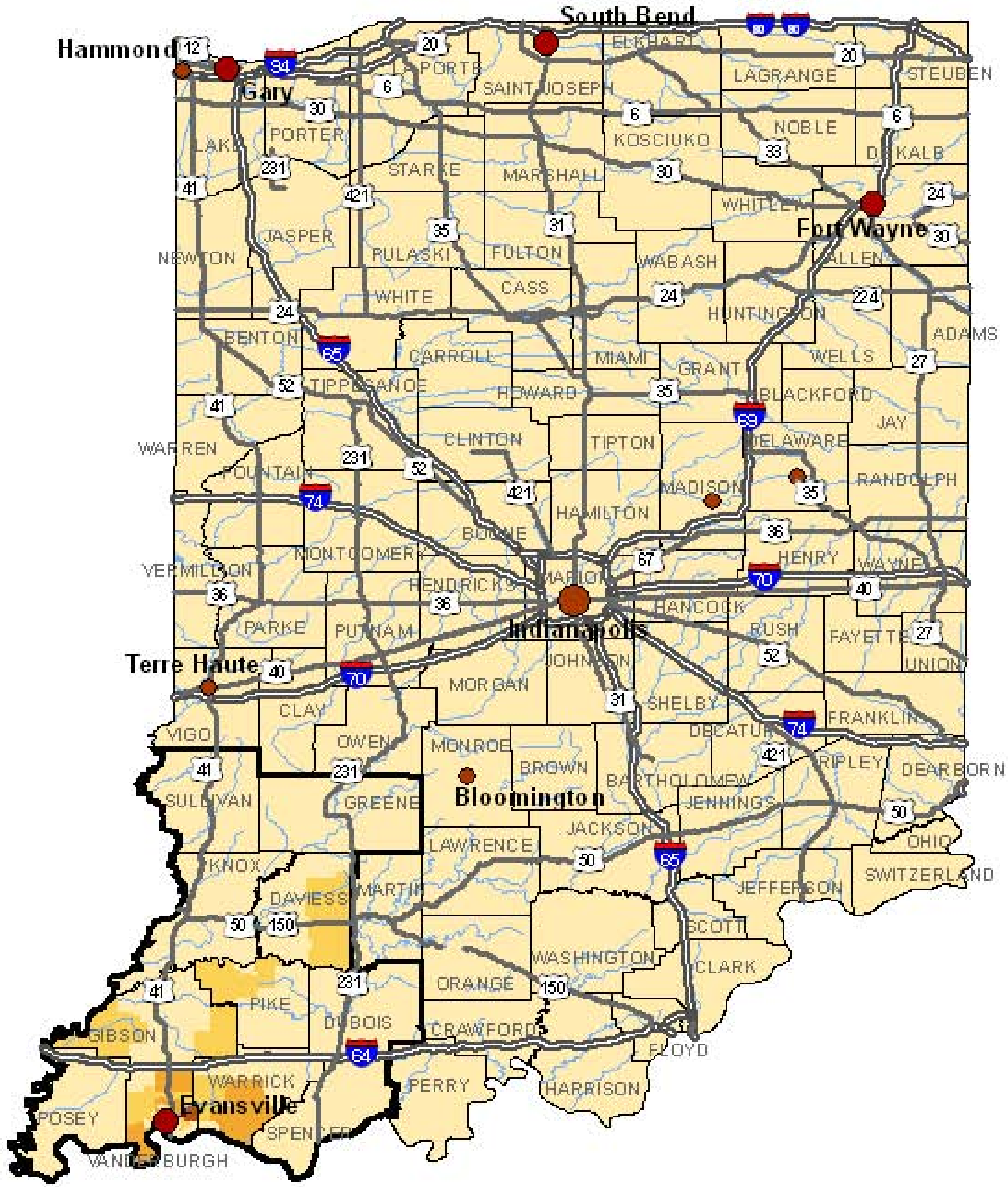
Worst Case Casualties (5PM) - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Daviess	4	0	4
Dubois	4	0	4
Gibson	12	1	13
Greene	1	0	1
Knox	2	0	2
Pike	9	0	9
Posey	6	0	6
Spencer	2	0	2
Sullivan	1	0	1
Vanderburgh	119	3	122
Warrick	24	1	24

Legend

Casualties (5PM)

- 0 - 2
- 2 - 4
- 4 - 8
- 8 - 12
- 12 - 18

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

Interstates

US Routes

Critical Counties

Rivers

0 10 20 40 60

Miles

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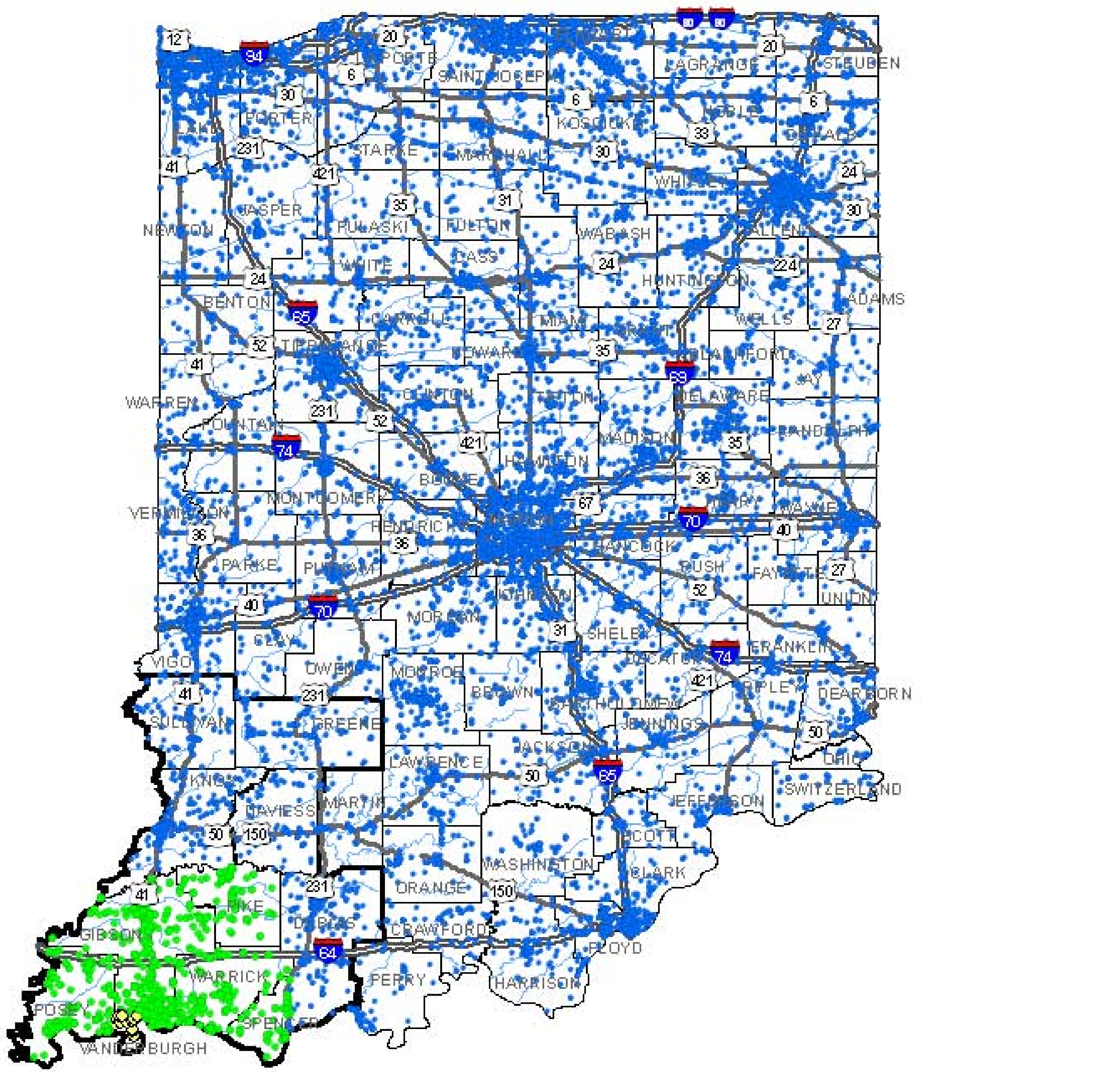
Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	167	0	0
Dubois	274	0	0
Gibson	235	0	0
Greene	155	0	0
Knox	301	0	0
Pike	127	0	0
Posey	200	0	0
Spencer	127	0	0
Sullivan	184	0	0
Vanderburgh	507	0	0
Warrick	213	0	0

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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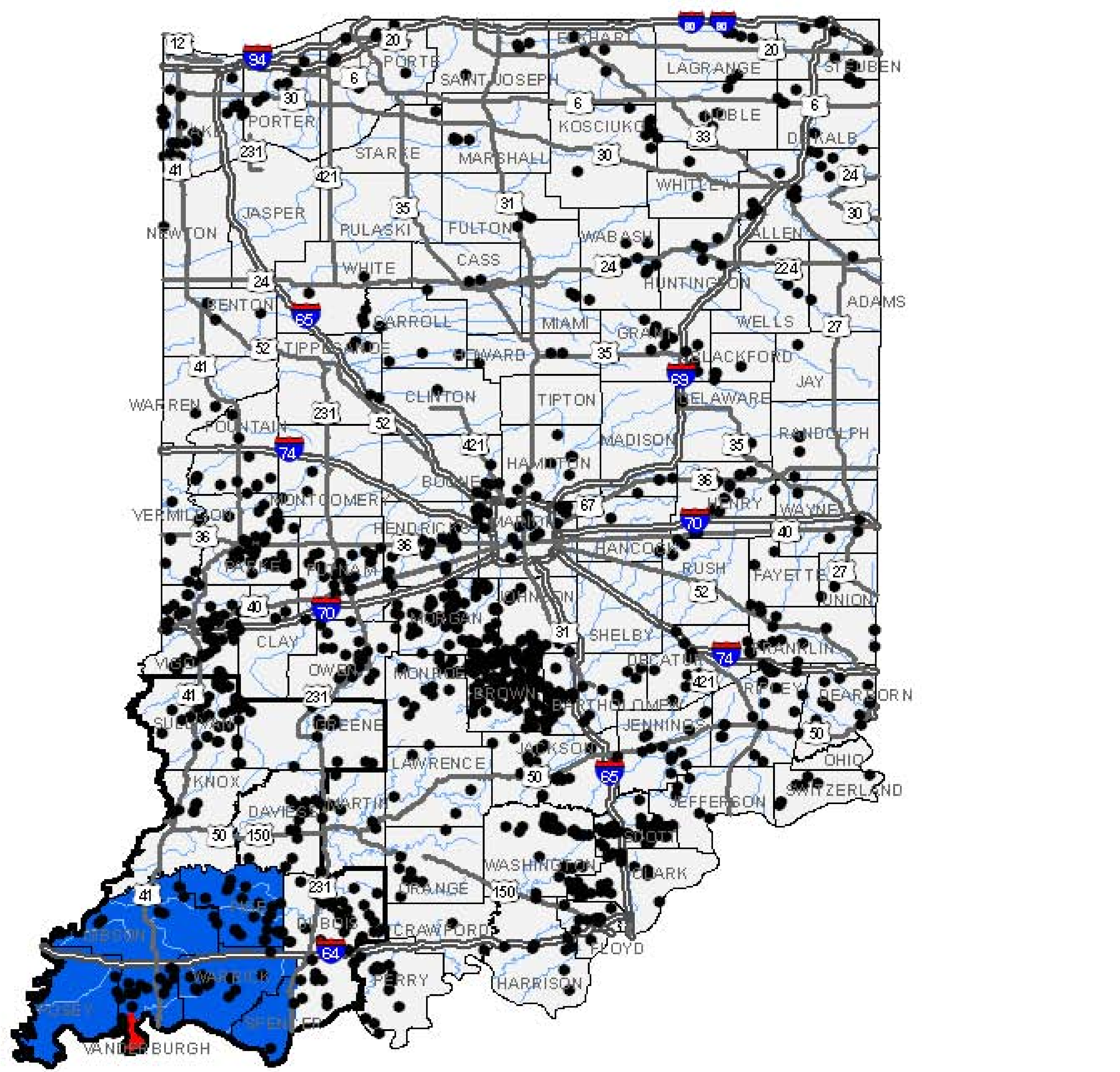
Dams - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Facilities
Daviess	14
Dubois	34
Gibson	8
Greene	19
Knox	6
Pike	25
Posey	5
Spencer	11
Sullivan	31
Vanderburgh	22
Warrick	15

Legend

MMI

- <VI
- VI
- VII
- Interstates
- US Routes
- Critical Counties
- Rivers
- Dams

0 10 20 40 60

Miles

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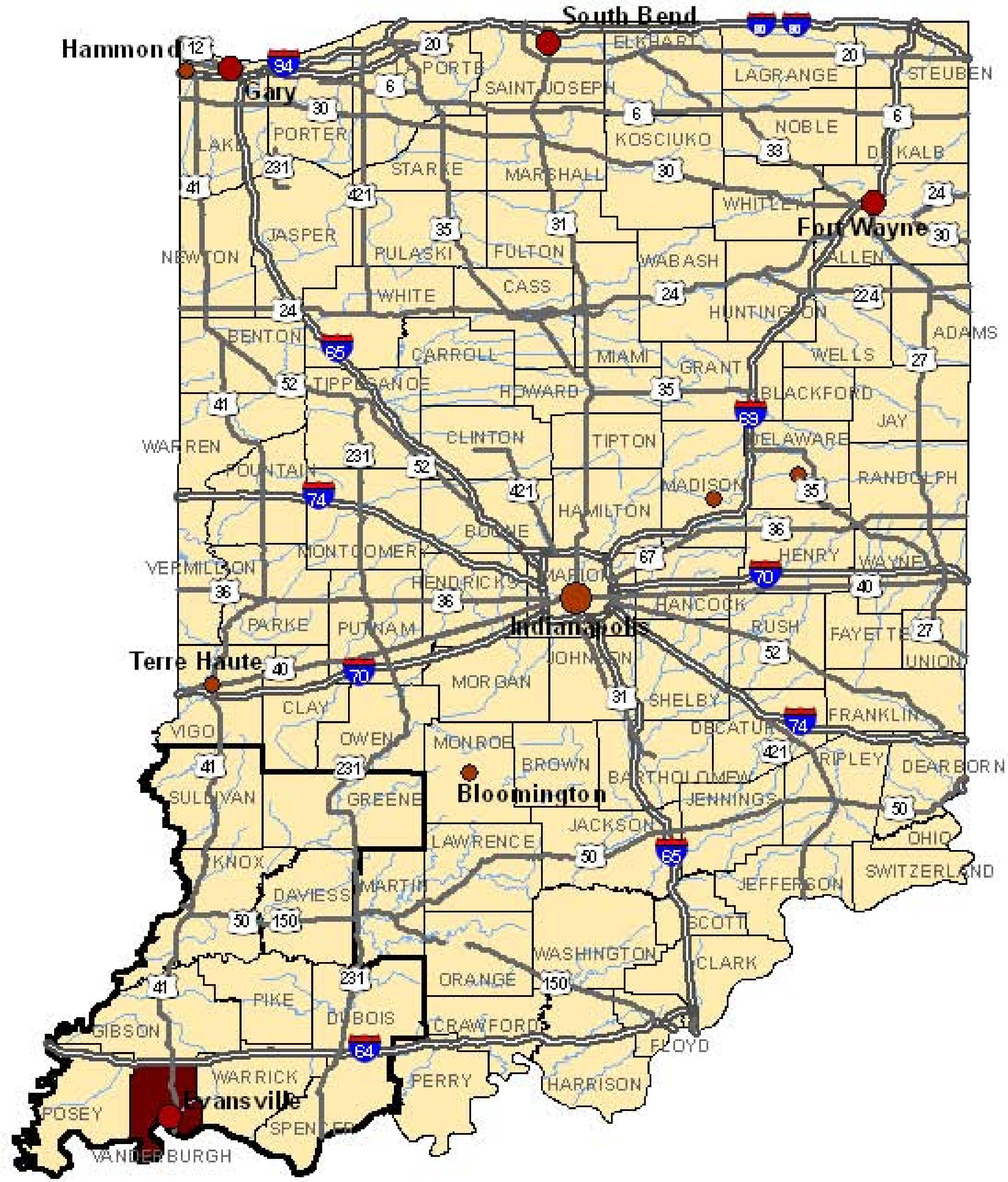
Displaced Population - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Displaced Residences	Estimate of Displaced Population
Daviess	0	0
Dubois	0	0
Gibson	0	0
Greene	0	0
Knox	0	0
Pike	0	0
Posey	0	0
Spencer	0	0
Sullivan	0	0
Vanderburgh	20	48
Warrick	2	4

Legend

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

Interstates

US Routes

Critical Counties

Displaced Population

dis_pop

- 0 - 5
- 6 - 48

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

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Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Dubois	4	0	0
Gibson	8	0	0
Greene	7	0	0
Knox	15	0	0
Pike	14	0	0
Posey	7	0	0
Spencer	8	0	0
Sullivan	8	0	0
Vanderburgh	14	0	0
Warrick	12	0	0
Daviess	0	0	0

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Electric Transmission Lines
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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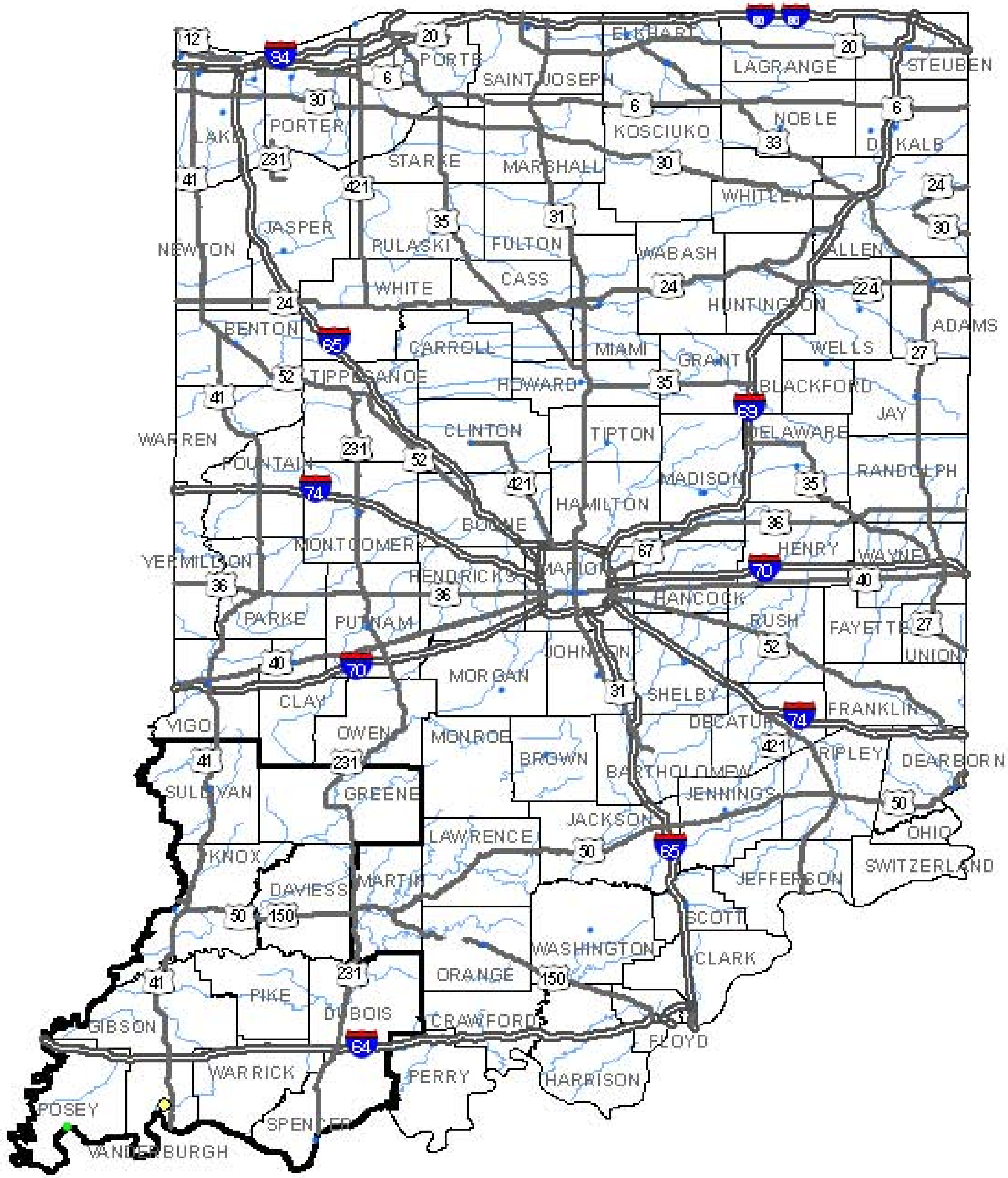
Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Knox	1	0	0
Posey	1	0	0
Spencer	1	0	0
Sullivan	2	0	0
Vanderburgh	1	0	0
Daviess	0	0	0
Dubois	0	0	0
Gibson	0	0	0
Greene	0	0	0
Pike	0	0	0
Warrick	0	0	0

Legend

Emergency Operation Centers At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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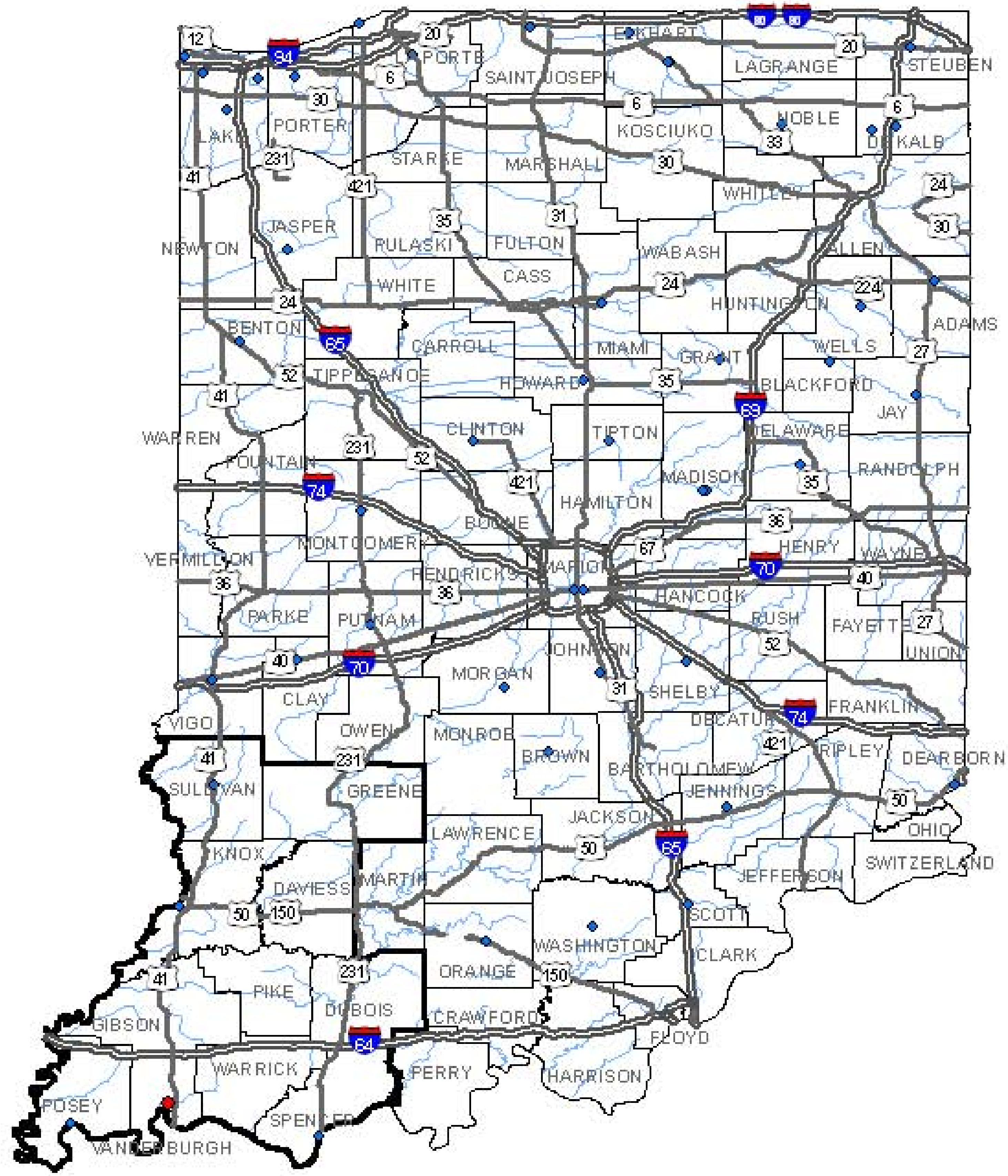
EOC Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Knox	1	1
Posey	1	1
Spencer	1	1
Sullivan	2	2
Vanderburgh	0	1
Daviess	0	0
Dubois	0	0
Gibson	0	0
Greene	0	0
Pike	0	0
Warrick	0	0

Legend

Emergency Operation Centers Functionality at Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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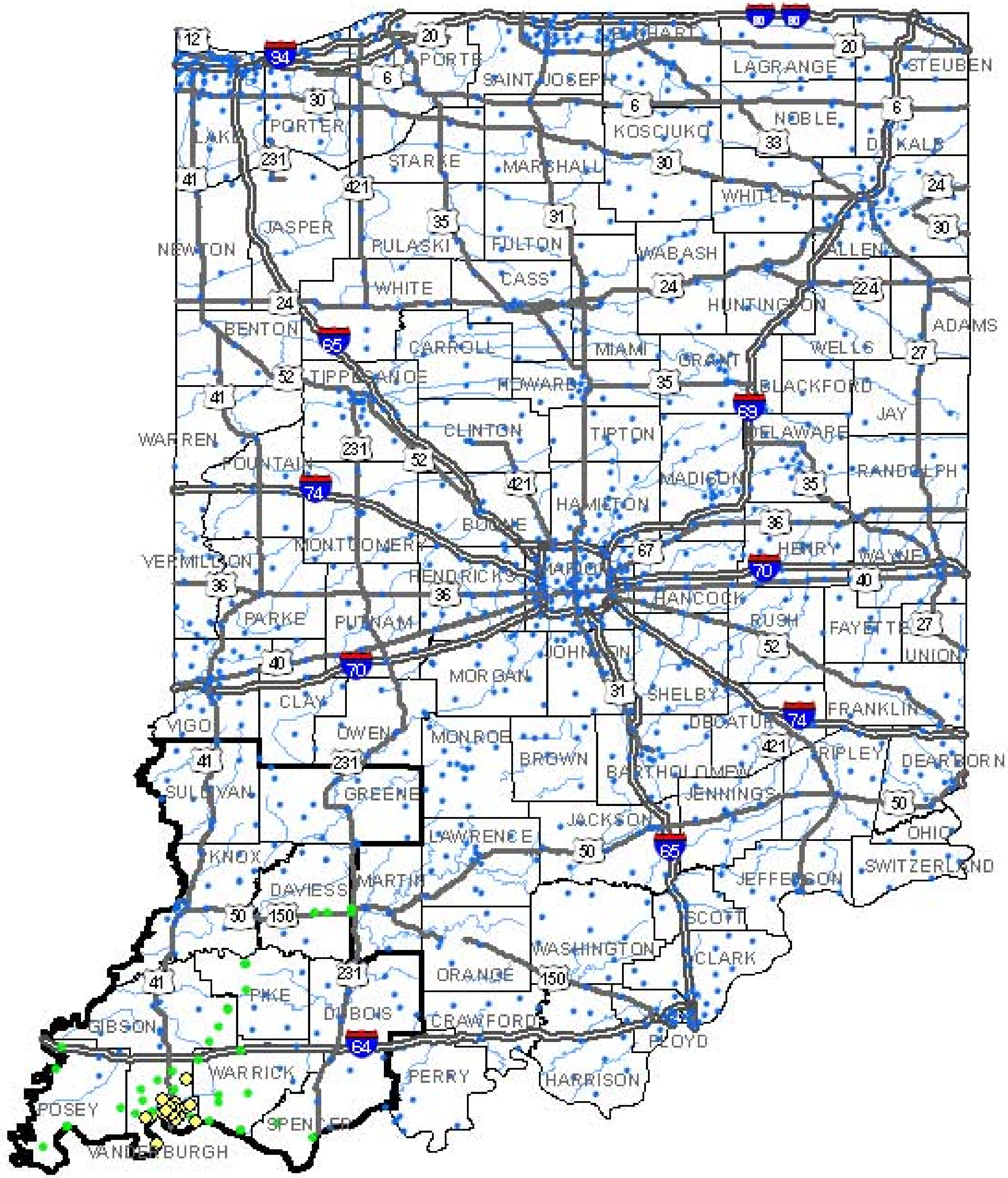
Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	12	0	0
Dubois	14	0	0
Gibson	13	0	0
Greene	14	0	0
Knox	19	0	0
Pike	8	0	0
Posey	10	0	0
Spencer	7	0	0
Sullivan	12	0	0
Vanderburgh	26	0	0
Warrick	11	0	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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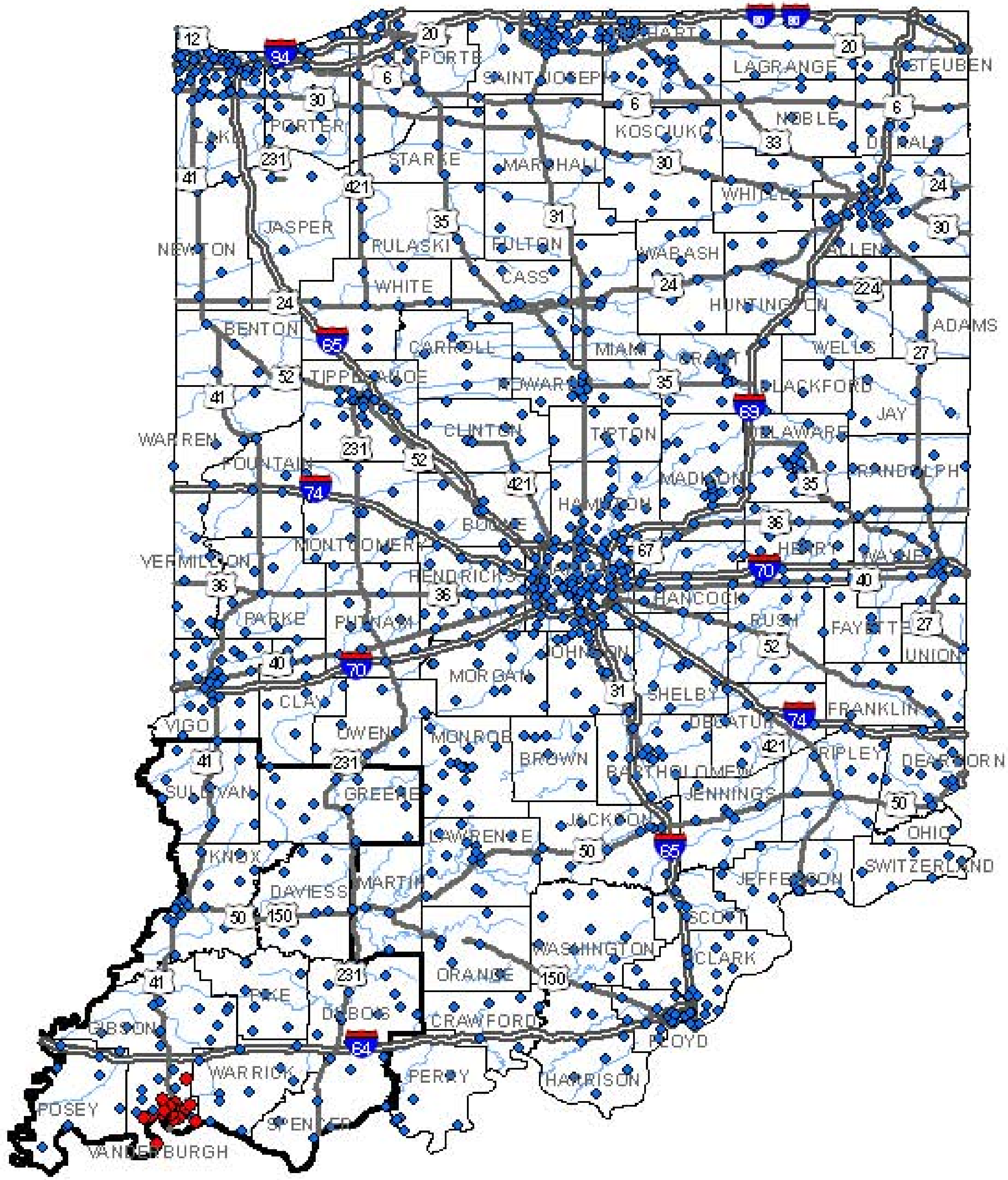
Fire Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	12	12
Dubois	14	14
Gibson	13	13
Greene	14	14
Knox	19	19
Pike	8	8
Posey	10	10
Spencer	7	7
Sullivan	12	12
Vanderburgh	8	26
Warrick	11	11

Legend

Fire Station Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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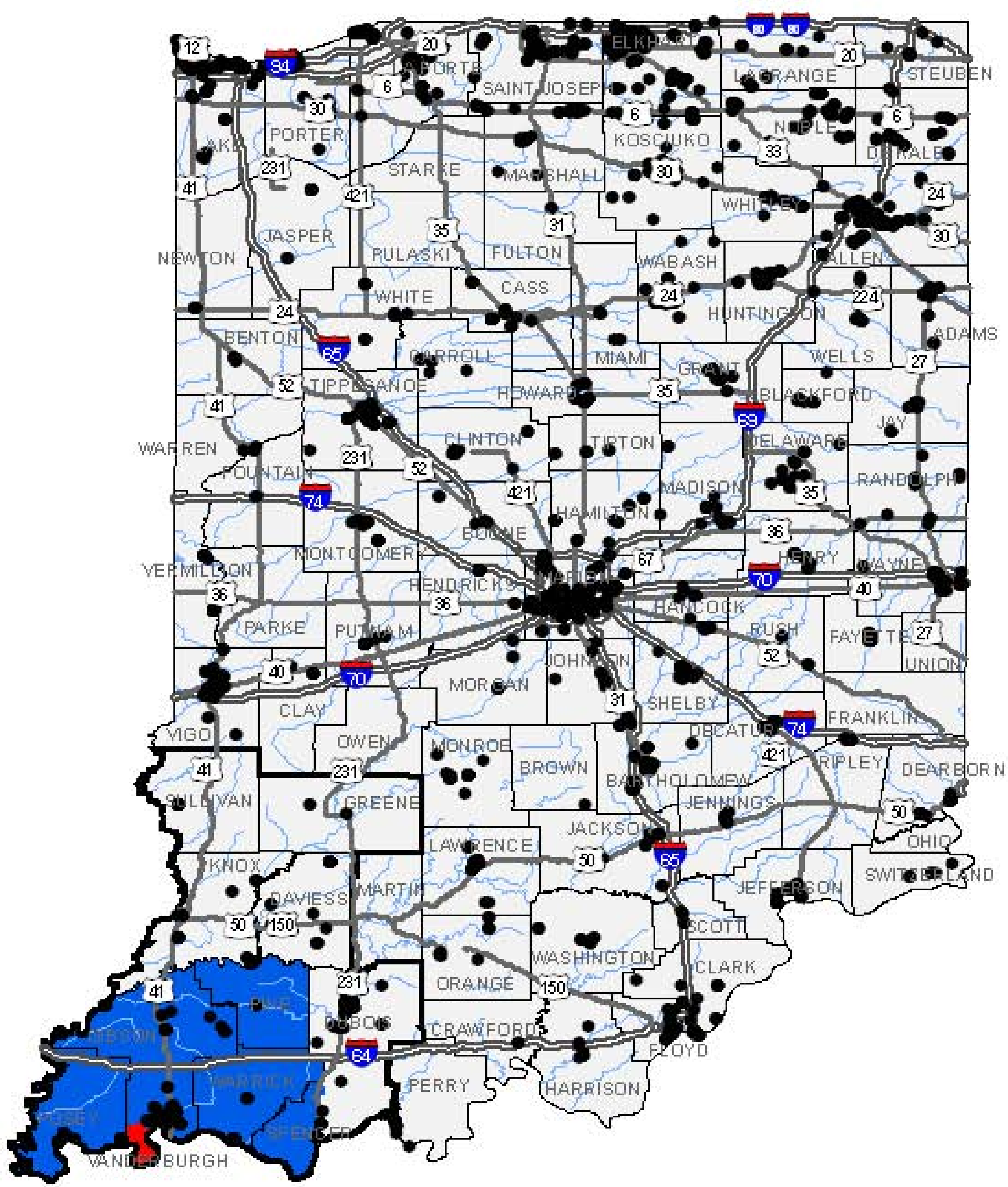
Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Facilities
Daviess	30
Dubois	62
Gibson	45
Greene	4
Knox	20
Pike	27
Posey	62
Spencer	24
Sullivan	16
Vanderburgh	73
Warrick	56

Legend

- Hazmat Facilities

MMI

- <VI
- VI
- VII

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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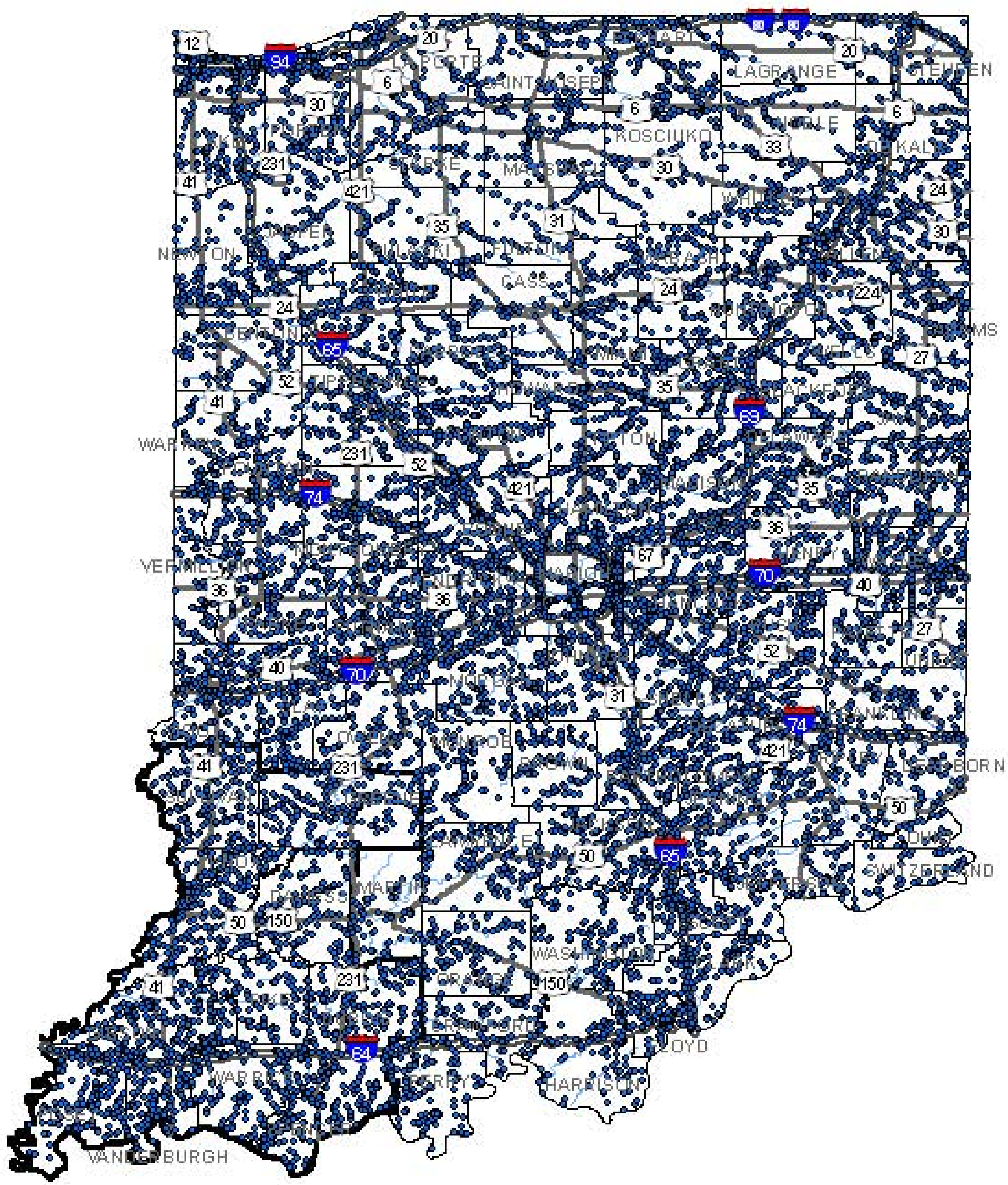
Highway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	136	136
Dubois	192	192
Gibson	293	293
Greene	201	201
Knox	288	288
Pike	136	136
Posey	191	191
Spencer	212	212
Sullivan	204	204
Vanderburgh	188	188
Warrick	173	173

Legend

Highway Bridge Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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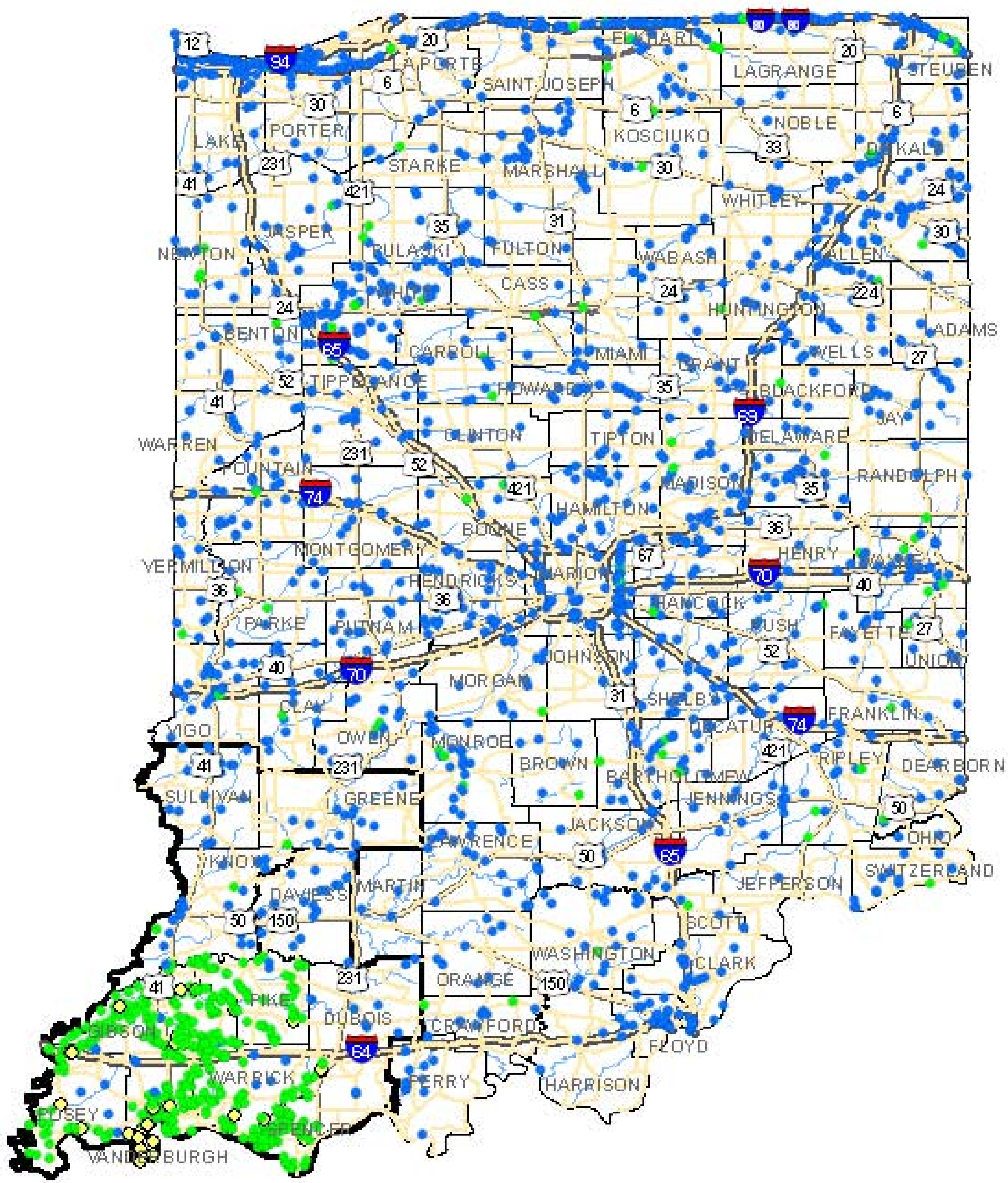
Highway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	136	0	0
Dubois	192	0	0
Gibson	293	0	0
Greene	201	0	0
Knox	288	0	0
Pike	136	0	0
Posey	191	0	0
Spencer	212	0	0
Sullivan	204	0	0
Vanderburgh	188	0	0
Warrick	173	0	0

Legend

Highway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Highway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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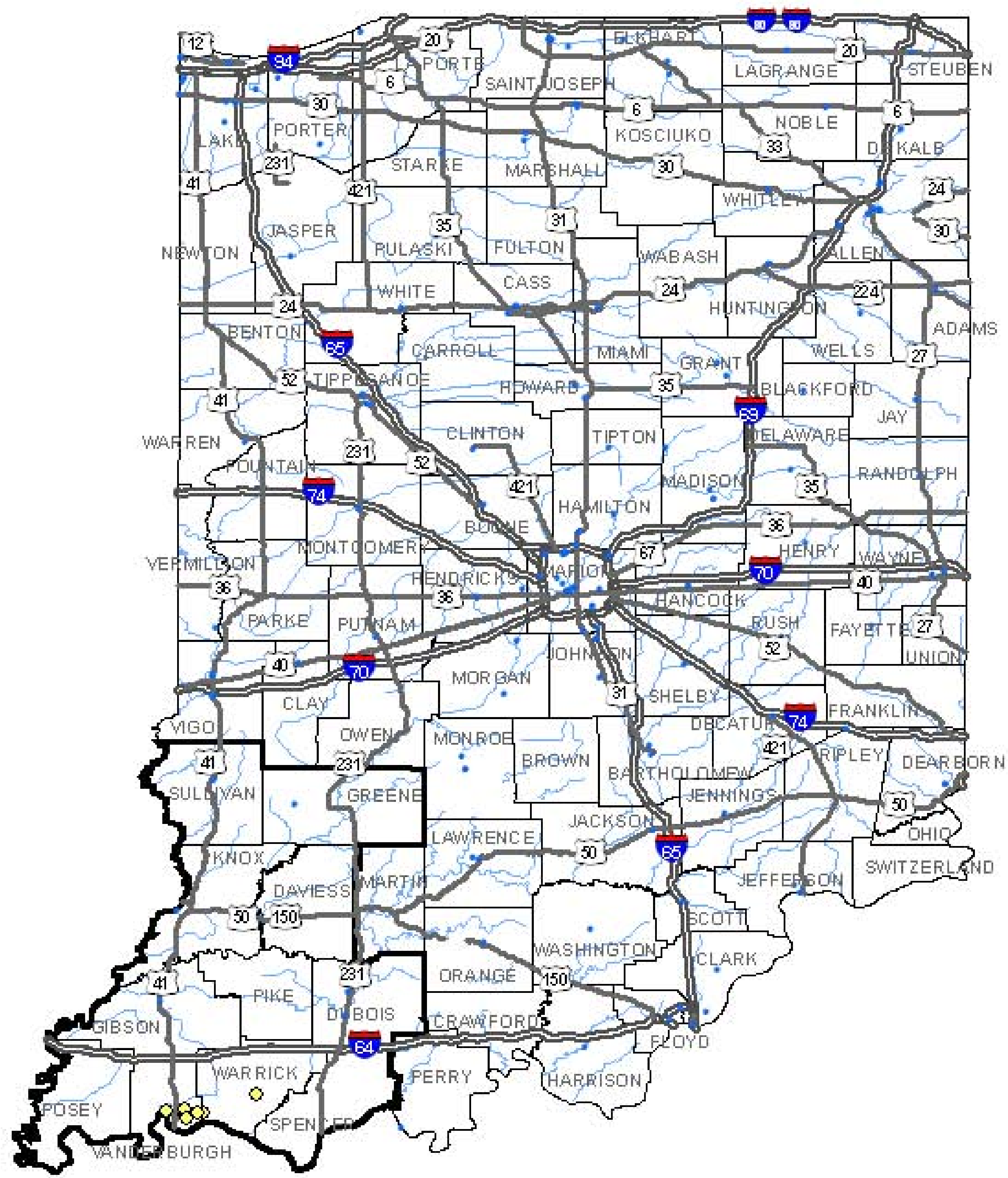
Hospital Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	1	0	0
Dubois	2	0	0
Gibson	1	0	0
Greene	1	0	0
Knox	1	0	0
Sullivan	1	0	0
Vanderburgh	7	0	0
Warrick	2	0	0
Pike	0	0	0
Posey	0	0	0
Spencer	0	0	0

Legend

Hospital Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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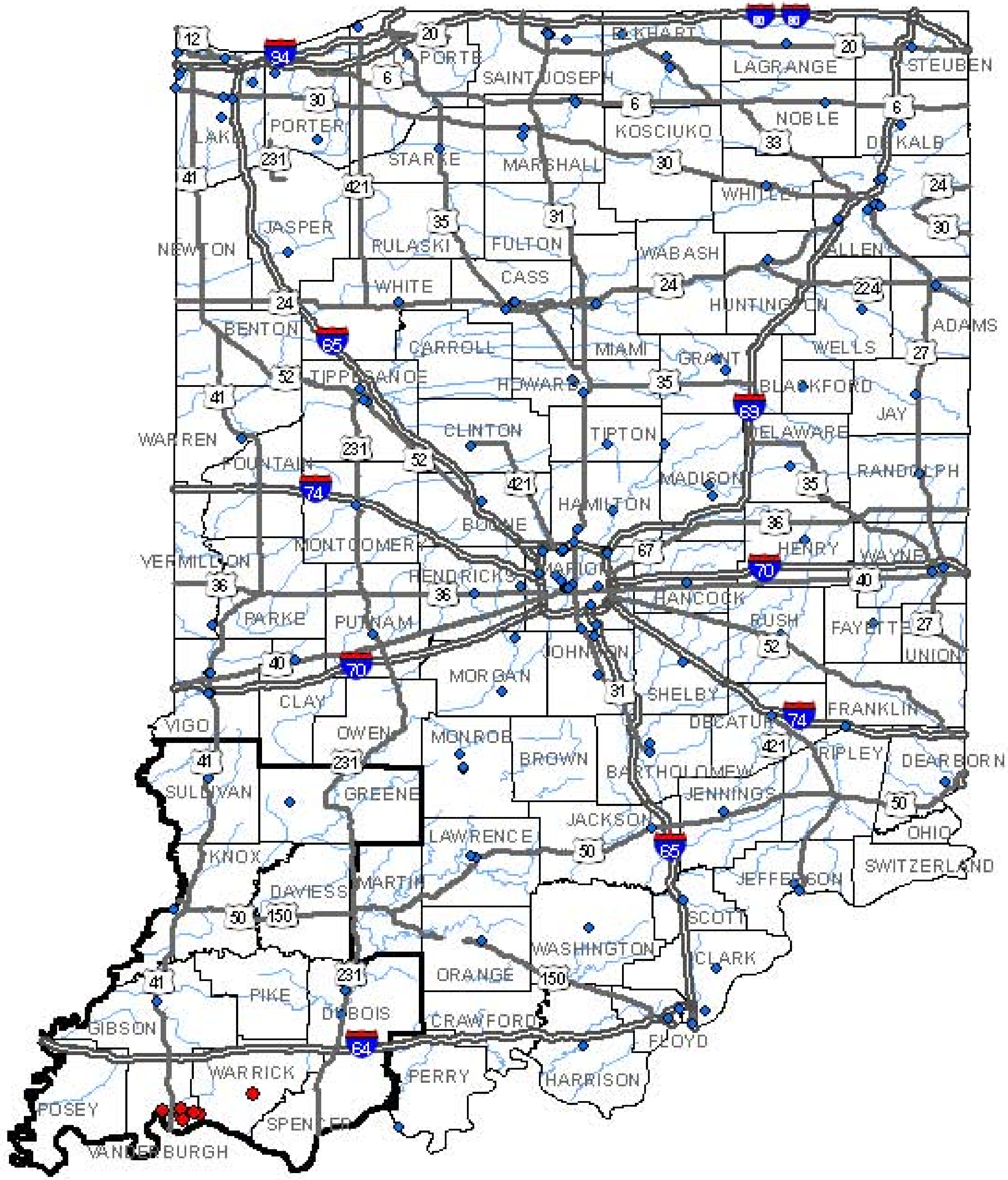
Hospital Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	1	1
Dubois	2	2
Gibson	1	1
Greene	1	1
Knox	1	1
Sullivan	1	1
Vanderburgh	0	7
Warrick	0	2
Pike	0	0
Posey	0	0
Spencer	0	0

Legend

Hospital Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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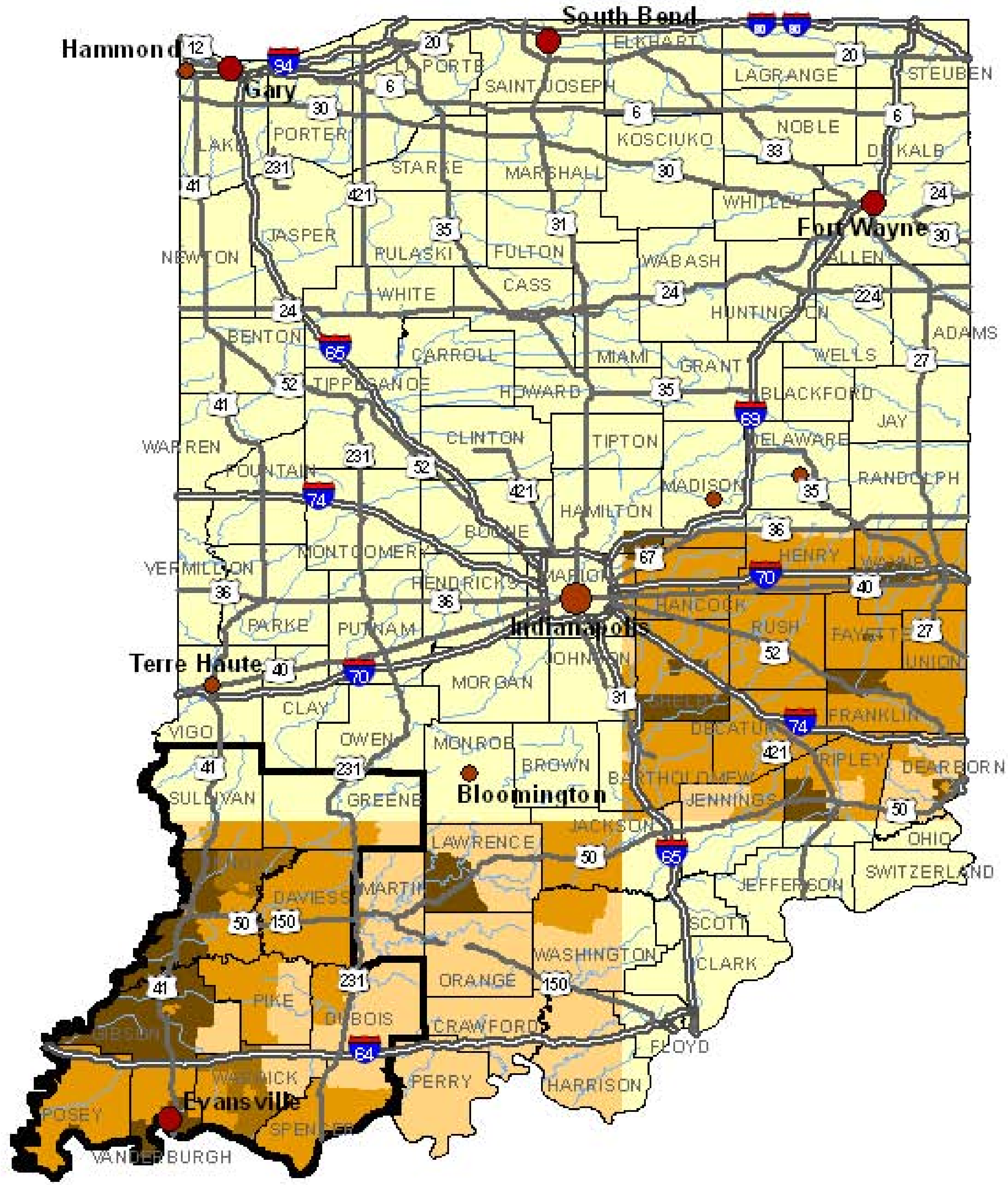
Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Minimum Susceptibility	Maximum Susceptibility
Daviess	Low	Low
Dubois	None	Low
Gibson	None	Very High
Greene	Unknown	Low
Knox	Low	Very High
Pike	None	Low
Posey	Low	Very High
Spencer	None	Low
Sullivan	Unknown	Low
Vanderburgh	Low	Very High
Warrick	None	Moderate

Legend

Liquefaction Susceptibility

- Unknown
- None
- Low
- Moderate
- Very High

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

Interstates
US Routes
Critical Counties
Rivers

0 10 20 40 60
Miles

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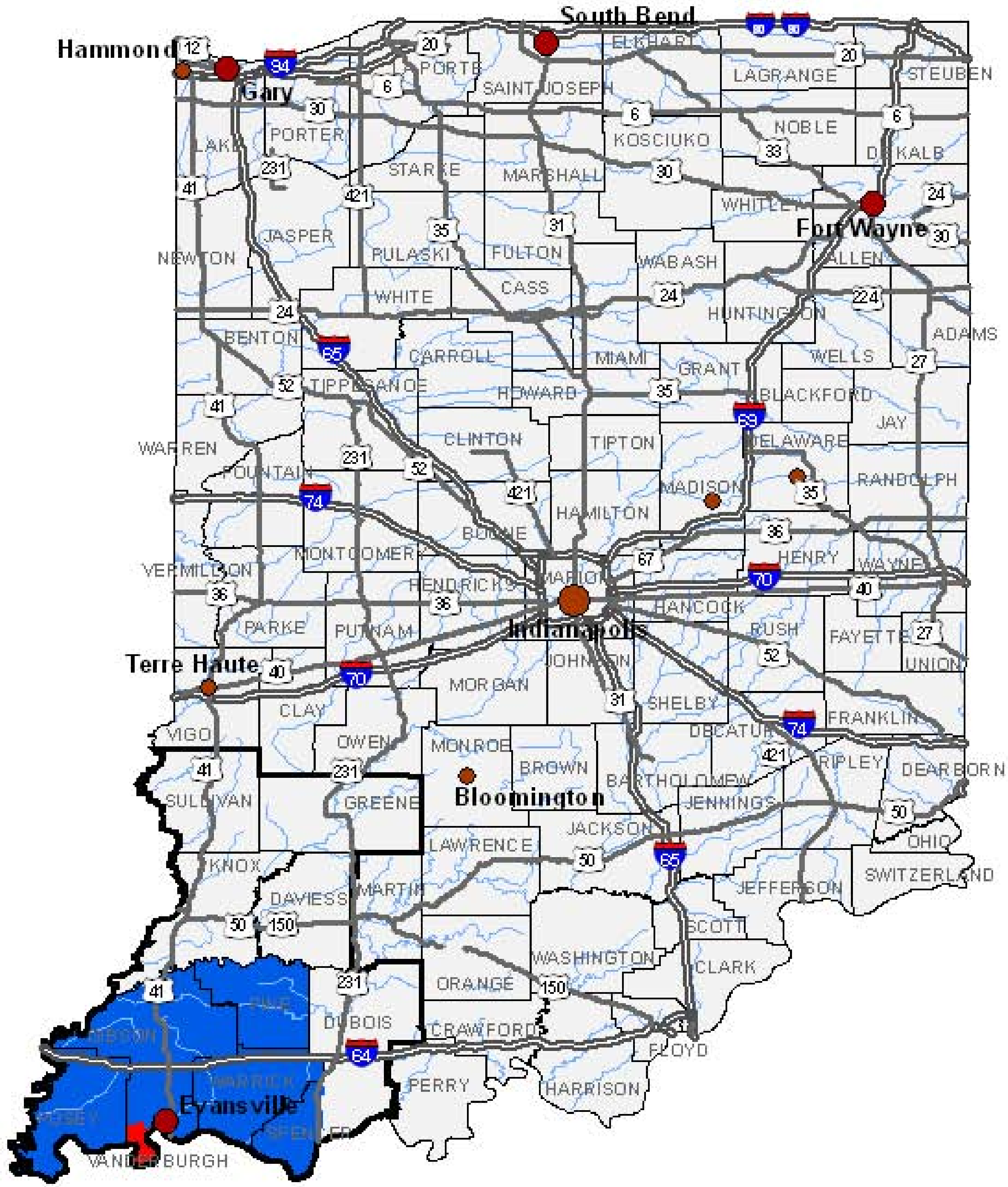
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Max. MMI
Daviess	VI
Dubois	< VI
Gibson	VI
Greene	< VI
Knox	VI
Pike	VI
Posey	VI
Spencer	VI
Sullivan	< VI
Vanderburgh	VII
Warrick	VI

Legend

MMI

- <VI
- VI
- VII

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

Interstates

US Routes

Critical Counties

Rivers

0 10 20 40 60

Miles

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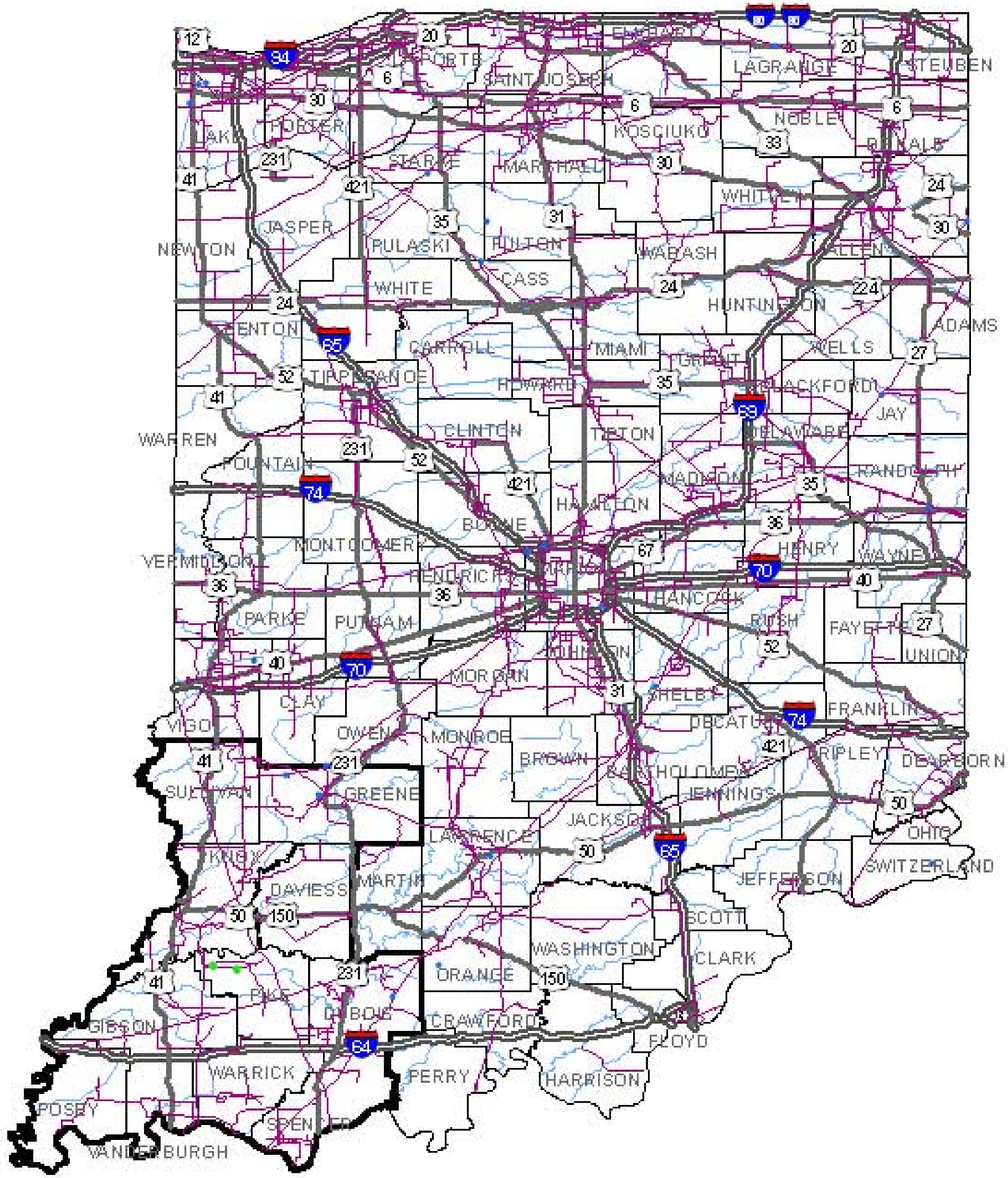
Natural Gas Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Dubois	1	0	0
Greene	4	0	0
Pike	2	0	0
Daviess	0	0	0
Gibson	0	0	0
Knox	0	0	0
Posey	0	0	0
Spencer	0	0	0
Sullivan	0	0	0
Vanderburgh	0	0	0
Warrick	0	0	0

Legend

Natural Gas Facility Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Natural Gas Pipelines
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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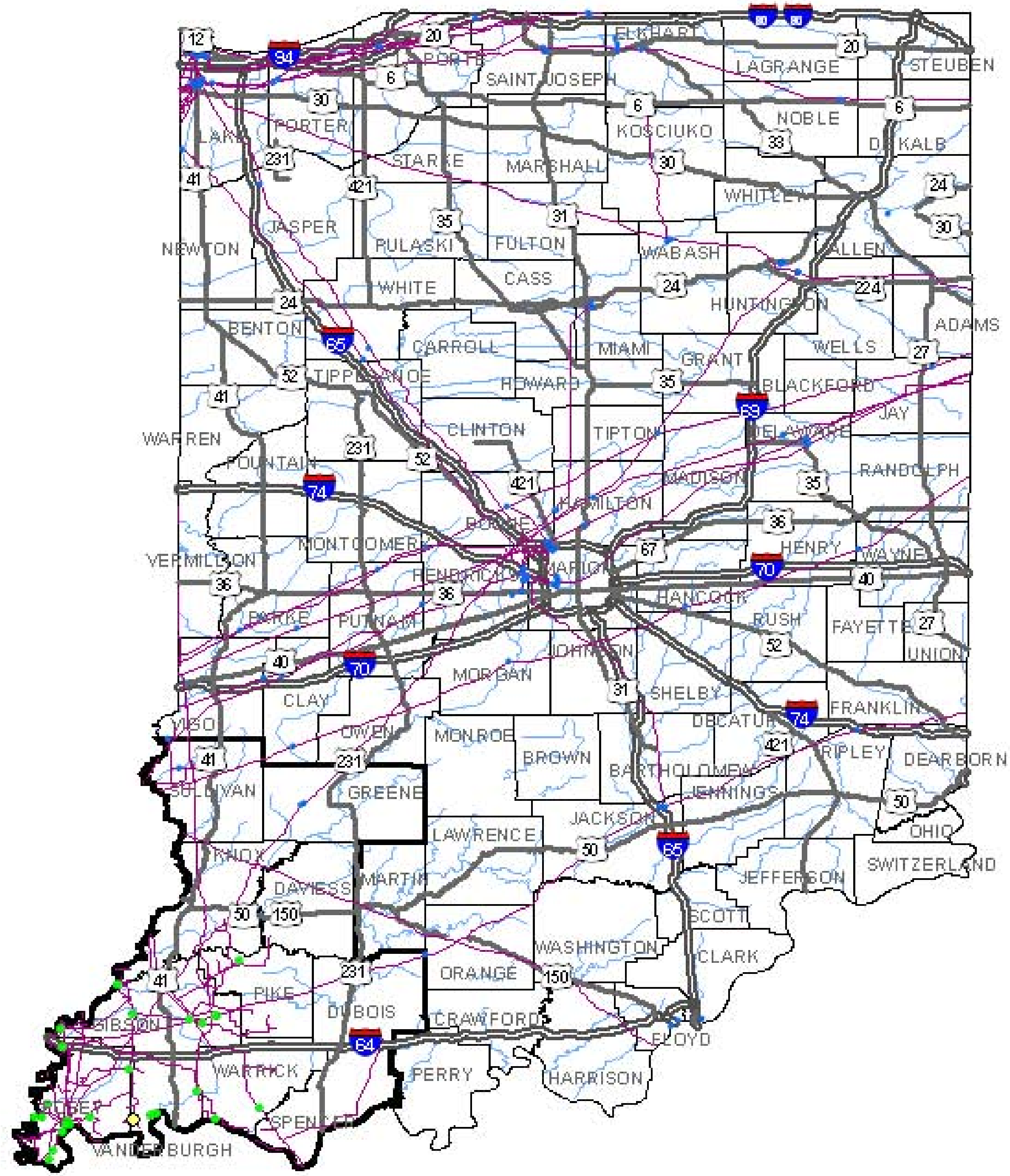
Oil Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Gibson	7	0	0
Greene	2	0	0
Pike	1	0	0
Posey	14	0	0
Sullivan	2	0	0
Vanderburgh	6	0	0
Warrick	3	0	0
Daviess	0	0	0
Dubois	0	0	0
Knox	0	0	0
Spencer	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Oil Pipelines
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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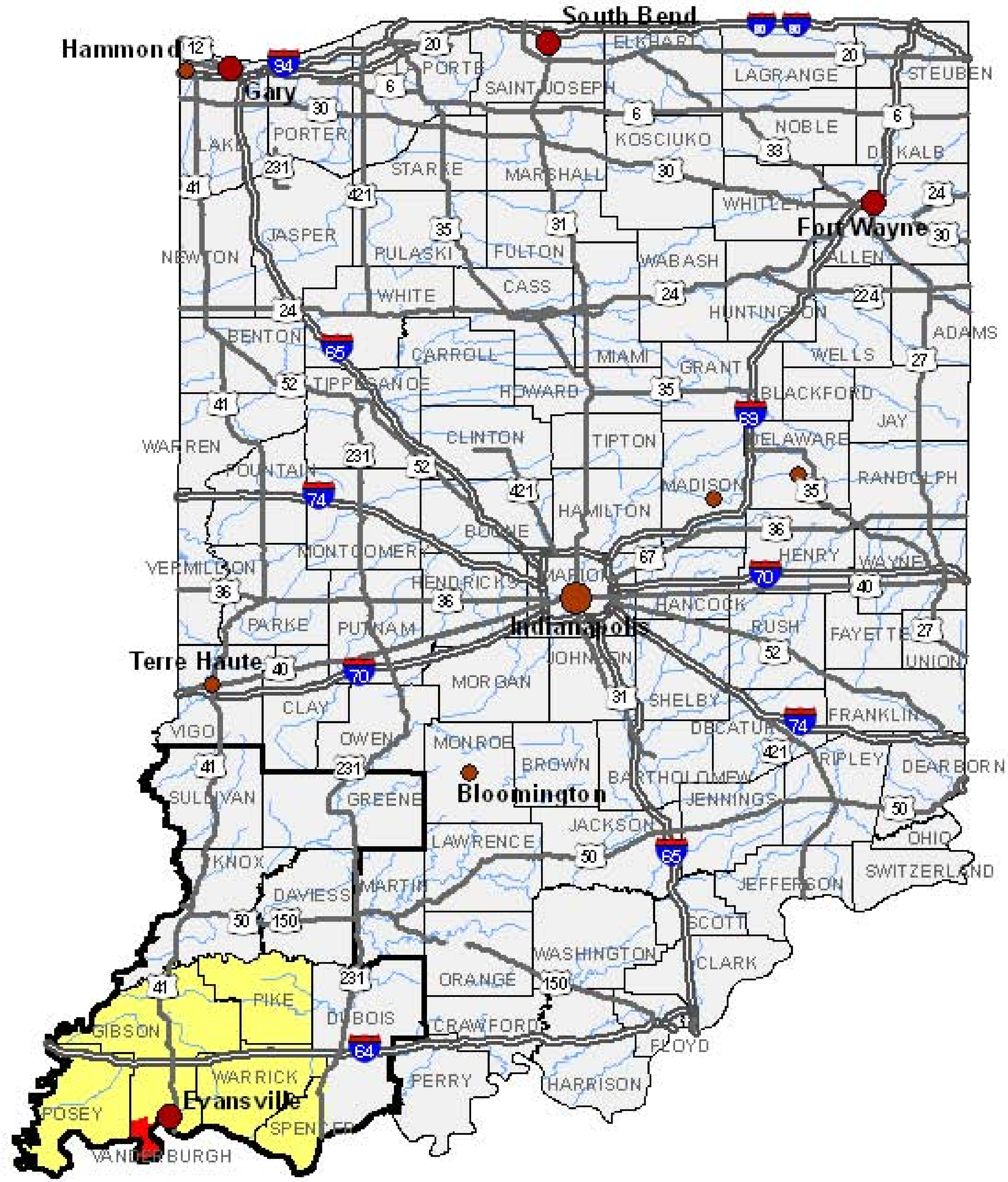
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Min. PGA	Max. PGA
Daviess	0.05	0.15
Dubois	0.06	0.06
Gibson	0.06	0.15
Greene	0.05	0.06
Knox	0.05	0.15
Pike	0.15	0.15
Posey	0.15	0.15
Spencer	0.06	0.15
Sullivan	0.05	0.05
Vanderburgh	0.15	0.25
Warrick	0.15	0.15

Legend

PGA (g)

- 0.05 - 0.1
- 0.1 - 0.15
- 0.15 - 0.2
- 0.2 - 0.25

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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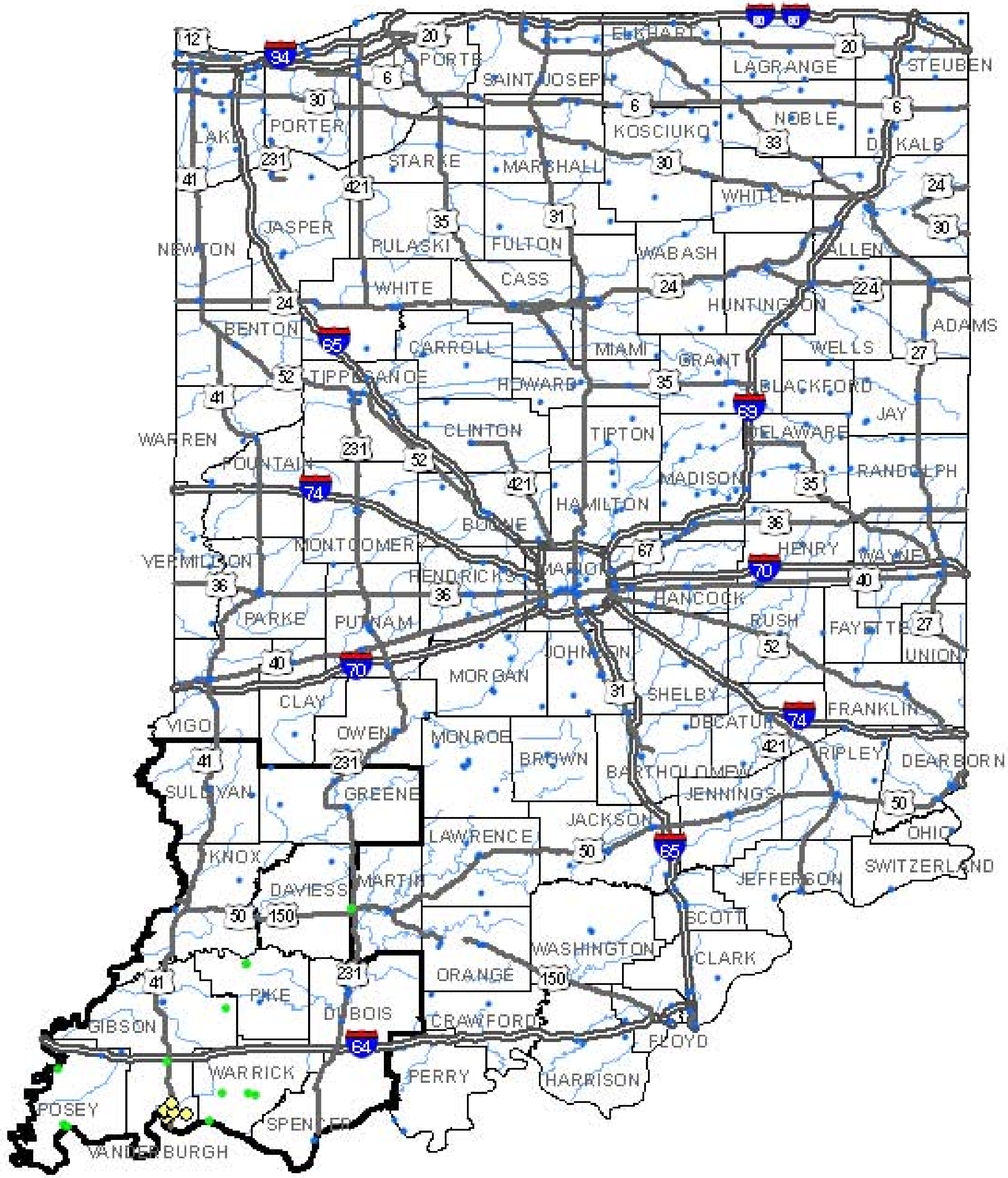
Police Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	3	0	0
Dubois	5	0	0
Gibson	3	0	0
Greene	5	0	0
Knox	3	0	0
Pike	4	0	0
Posey	5	0	0
Spencer	2	0	0
Sullivan	3	0	0
Vanderburgh	7	0	0
Warrick	4	0	0

Legend

Police Station Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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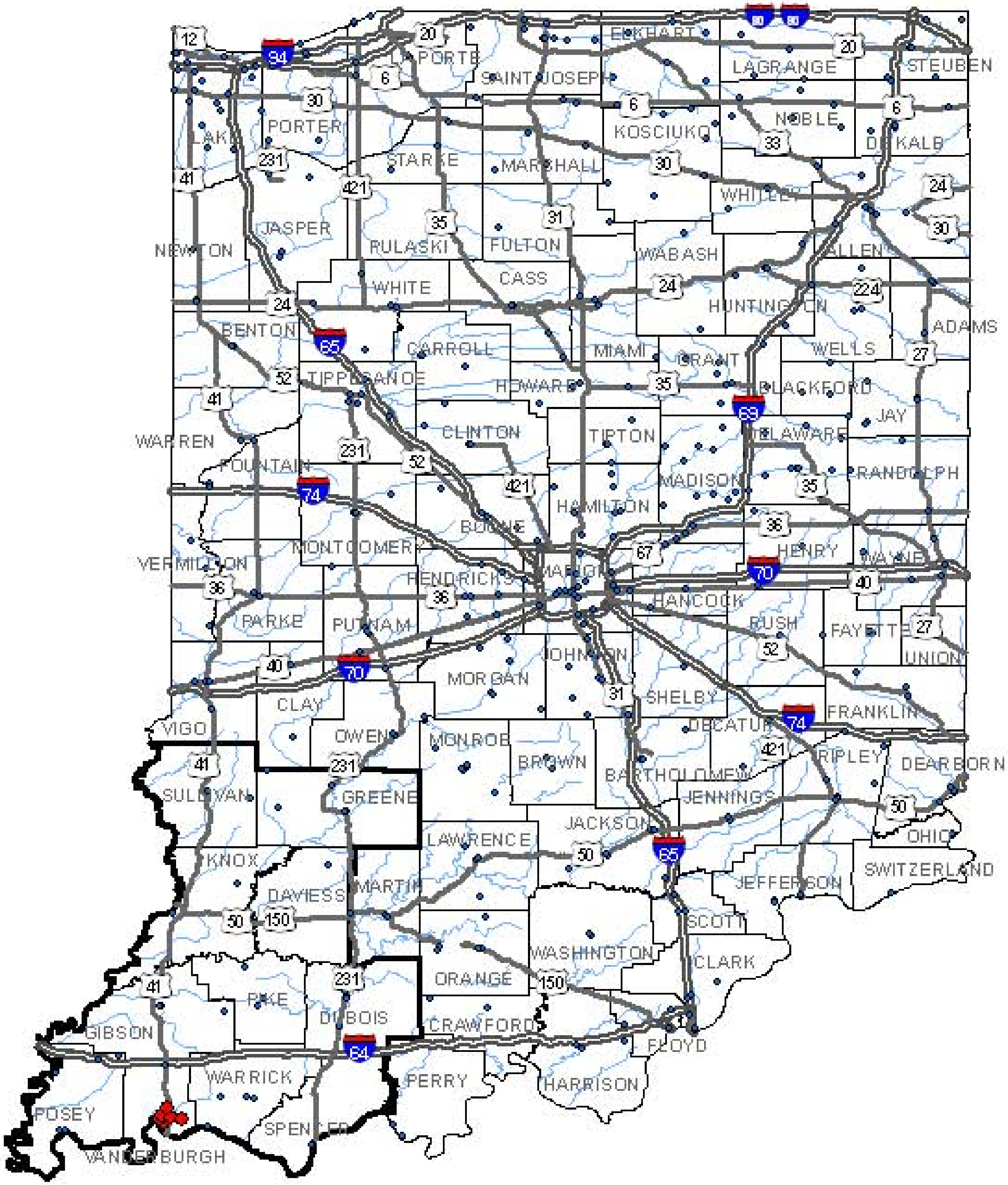
Police Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	3	3
Dubois	5	5
Gibson	3	3
Greene	5	5
Knox	3	3
Pike	4	4
Posey	5	5
Spencer	2	2
Sullivan	3	3
Vanderburgh	1	7
Warrick	4	4

Legend

Police Station Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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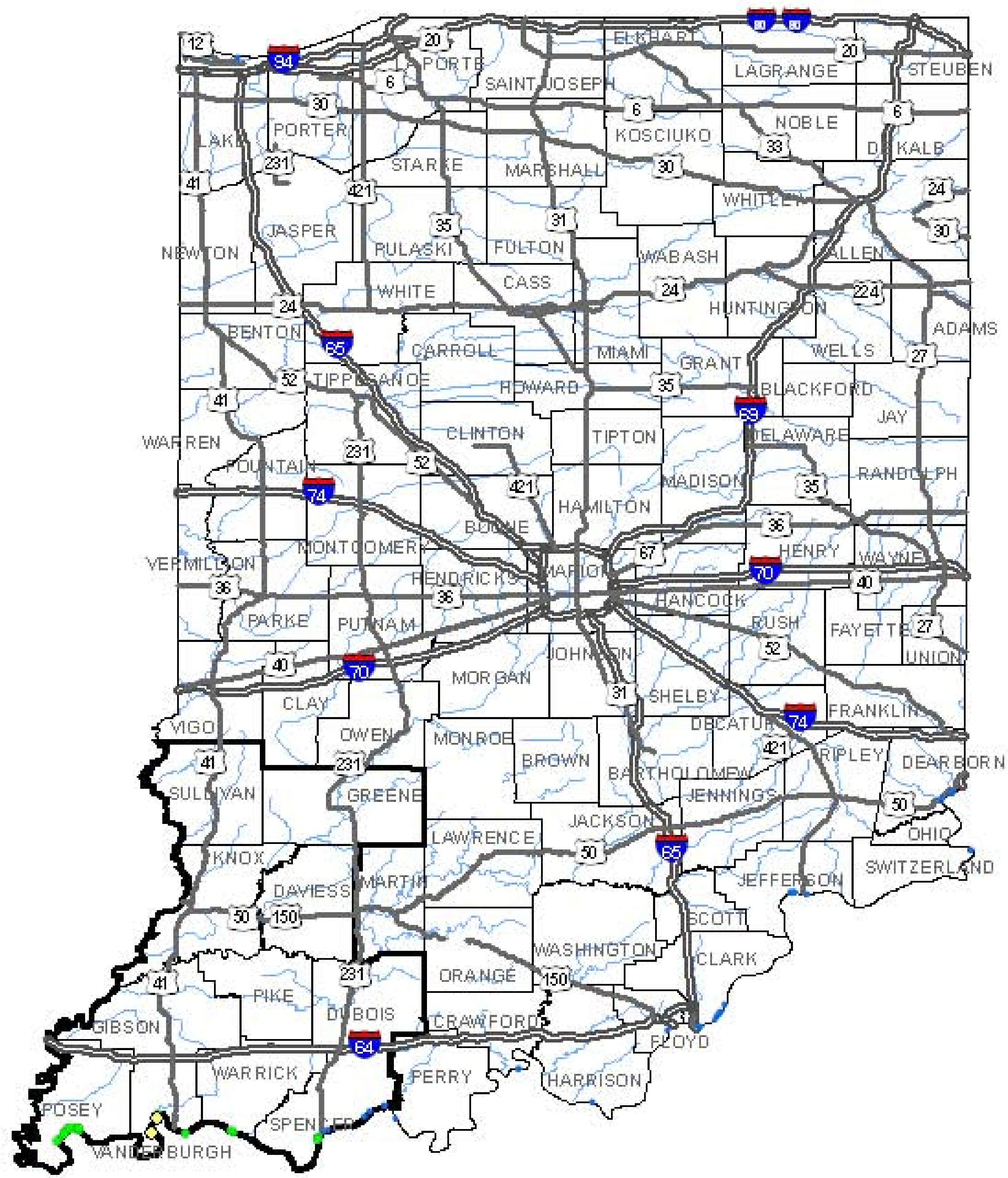
Port Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Posey	20	0	0
Spencer	10	0	0
Vanderburgh	4	0	0
Warrick	2	0	0
Daviess	0	0	0
Dubois	0	0	0
Gibson	0	0	0
Greene	0	0	0
Knox	0	0	0
Pike	0	0	0
Sullivan	0	0	0

Legend

Port Facility Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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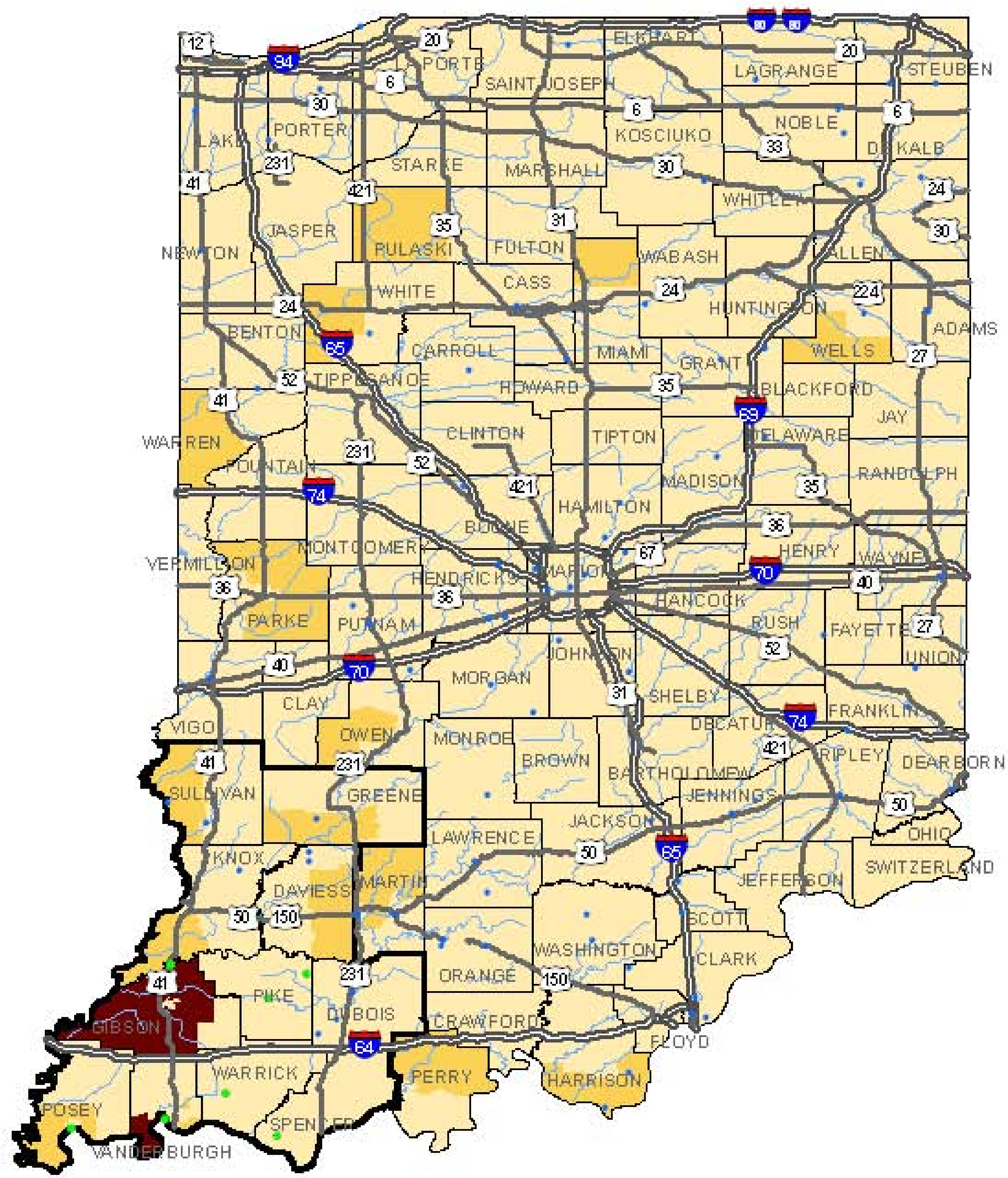
Potable Water Facilities Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	2	0	0
Dubois	3	0	0
Gibson	1	0	0
Greene	1	0	0
Knox	1	0	0
Pike	2	0	0
Posey	1	0	0
Spencer	1	0	0
Sullivan	2	0	0
Vanderburgh	1	0	0
Warrick	1	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Potable Water Pipeline Damage

No. of Leaks

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 37

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center

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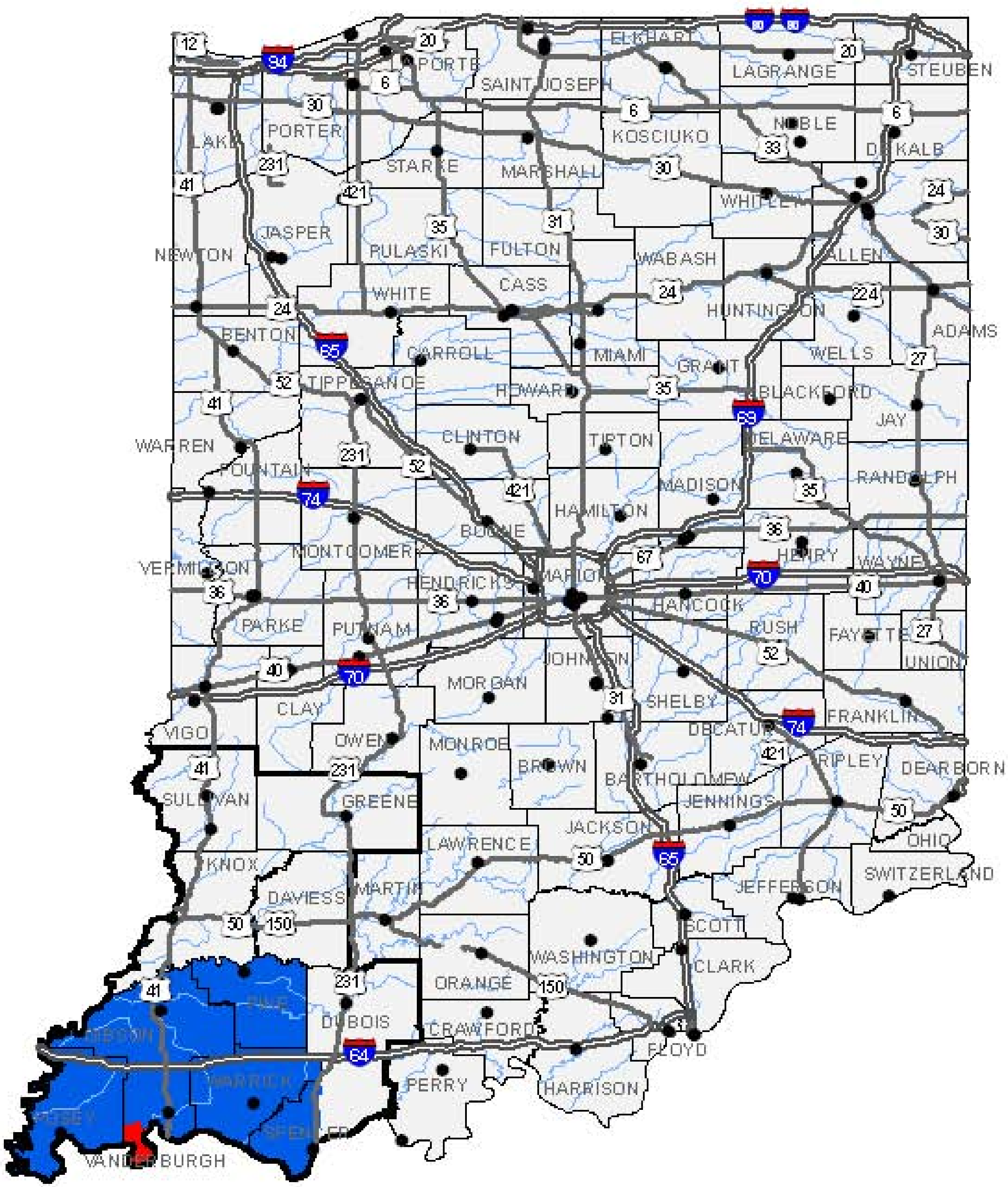
Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

Prisons - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Facilities
Daviess	1
Dubois	0
Gibson	1
Greene	1
Knox	1
Pike	1
Posey	1
Spencer	1
Sullivan	2
Vanderburgh	1
Warrick	1

Legend

- Prisons

MMI

- <VI
- VI
- VII

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

Mid-America Earthquake Center

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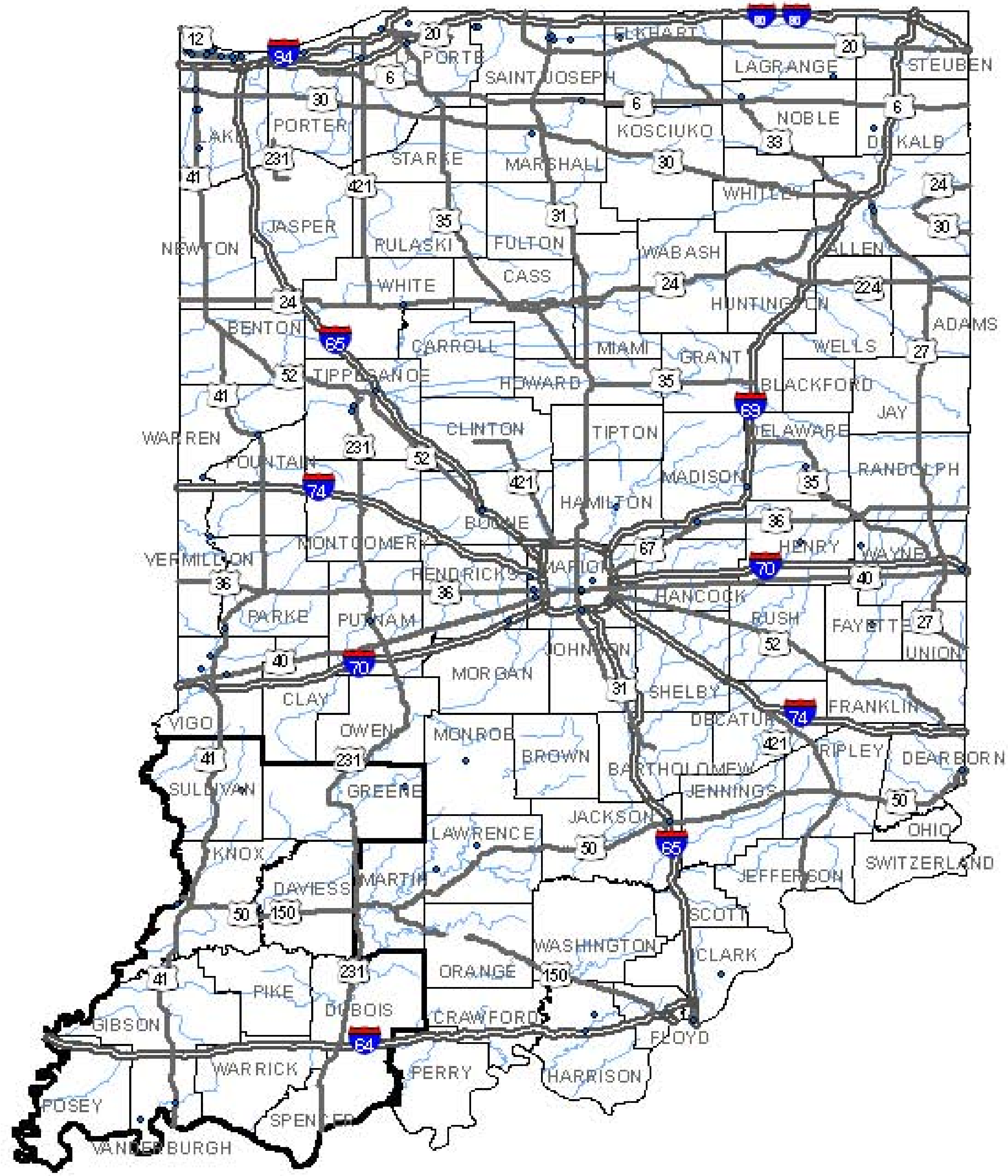
Railway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Greene	1	1
Knox	2	2
Sullivan	1	1
Vanderburgh	2	2
Daviess	0	0
Dubois	0	0
Gibson	0	0
Pike	0	0
Posey	0	0
Spencer	0	0
Warrick	0	0

Legend

Railway Bridge Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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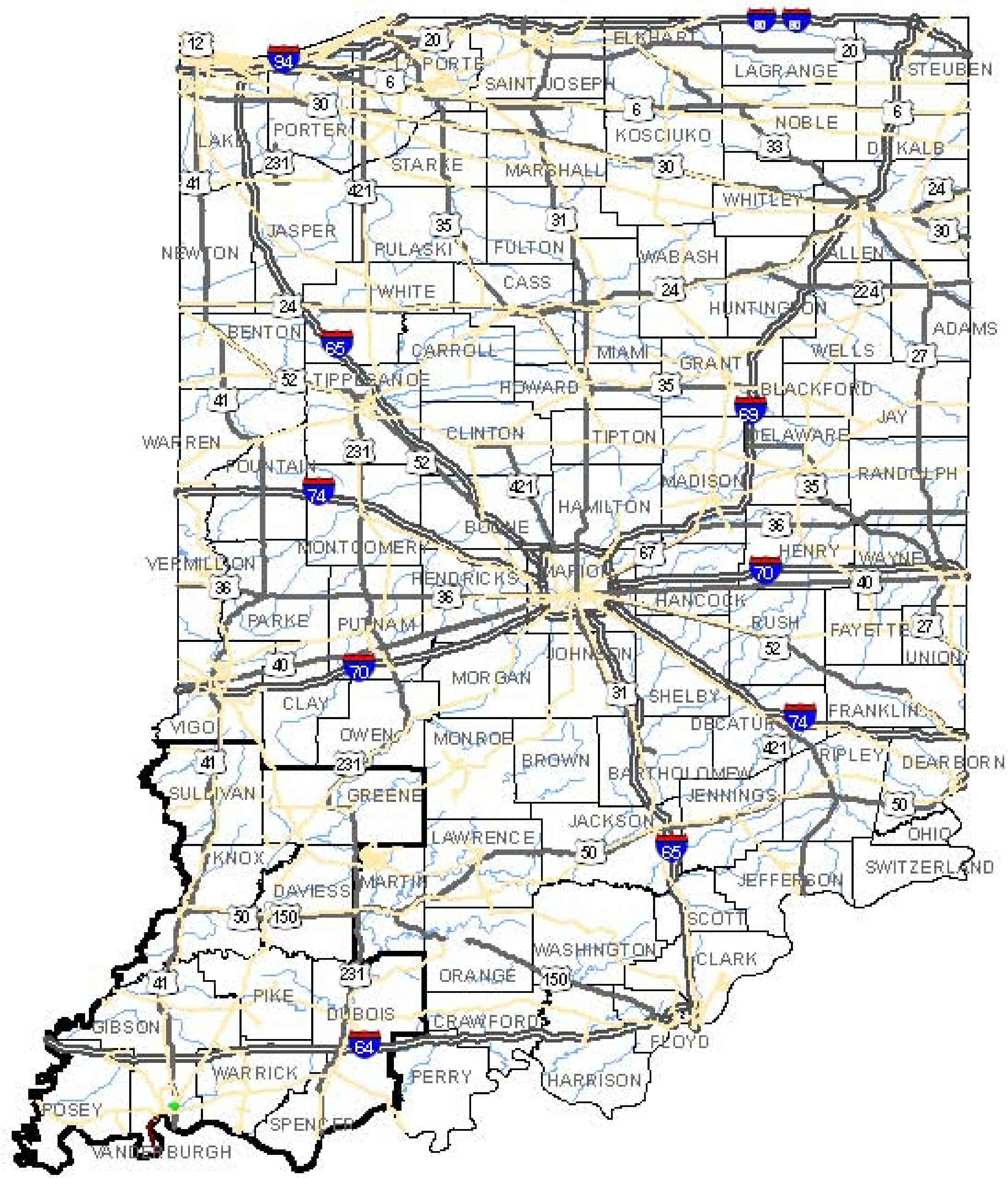
Railway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Greene	1	0	0
Knox	2	0	0
Sullivan	1	0	0
Vanderburgh	2	0	0
Daviess	0	0	0
Dubois	0	0	0
Gibson	0	0	0
Pike	0	0	0
Posey	0	0	0
Spencer	0	0	0
Warrick	0	0	0

Legend

Railway Bridge Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Railway Segment Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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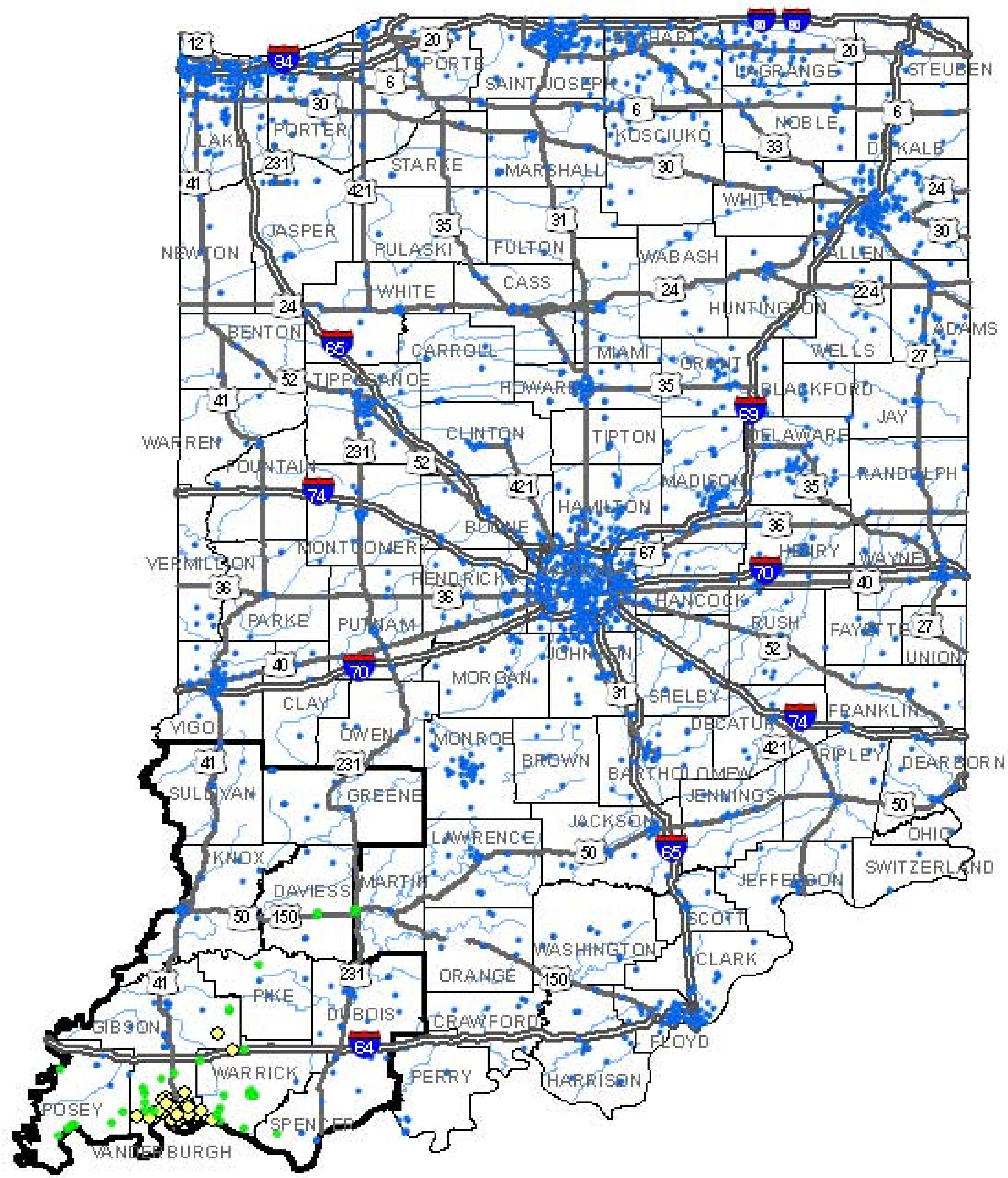
School Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana
Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	21	0	0
Dubois	21	0	0
Gibson	20	0	0
Greene	14	0	0
Knox	18	0	0
Pike	5	0	0
Posey	14	0	0
Spencer	13	0	0
Sullivan	10	0	0
Vanderburgh	66	0	0
Warrick	21	0	0

Legend

School Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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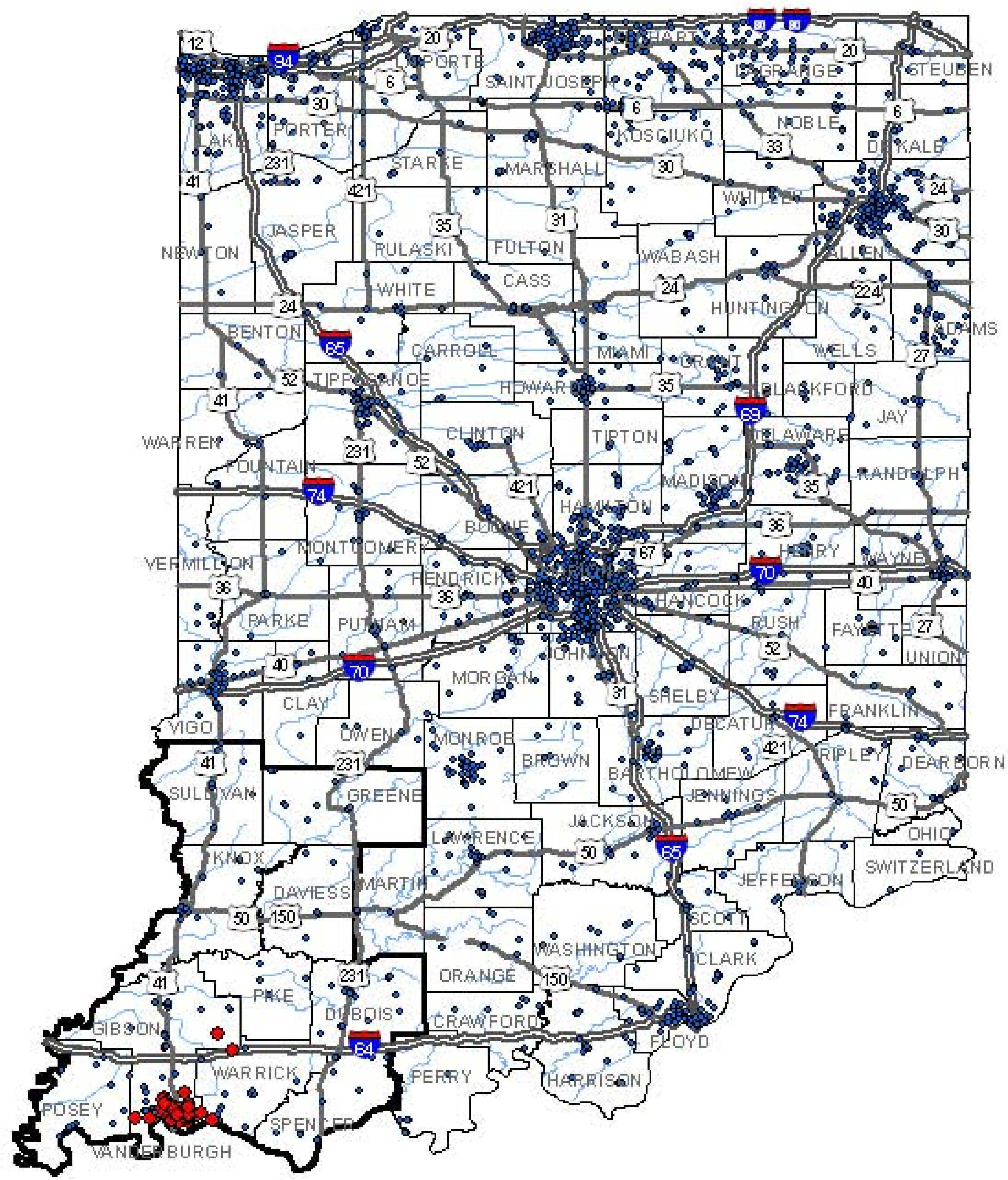
School Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	21	21
Dubois	21	21
Gibson	19	20
Greene	14	14
Knox	18	18
Pike	5	5
Posey	14	14
Spencer	13	13
Sullivan	10	10
Vanderburgh	14	66
Warrick	18	21

Legend

School Functionality

Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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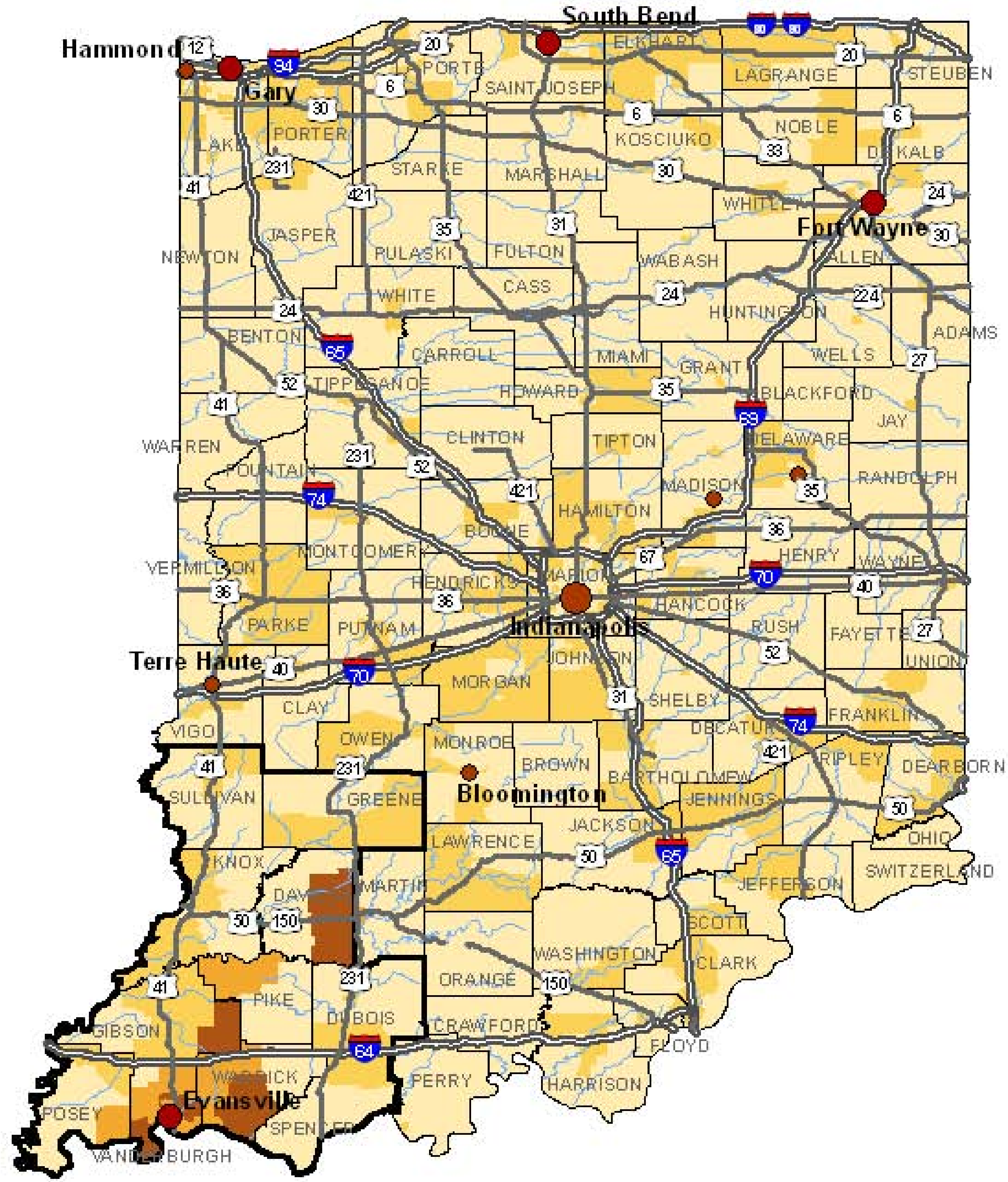
Total Debris - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Brick/ Wood (Tons)	Concrete/ Steel (Tons)	Total Debris (Tons)
Daviess	2,421	783	3,205
Dubois	2,877	877	3,754
Gibson	4,770	1,392	6,163
Greene	904	109	1,013
Knox	1,199	154	1,353
Pike	4,621	1,497	6,119
Posey	1,446	205	1,652
Spencer	609	78	686
Sullivan	519	58	578
Vanderburgh	84,735	58,734	143,469
Warrick	12,053	3,451	15,503

Legend

Total Debris

Tons

- 8 - 100
- 100 - 500
- 500 - 2,000
- 2,000 - 4,000
- 4,000 - 73,300

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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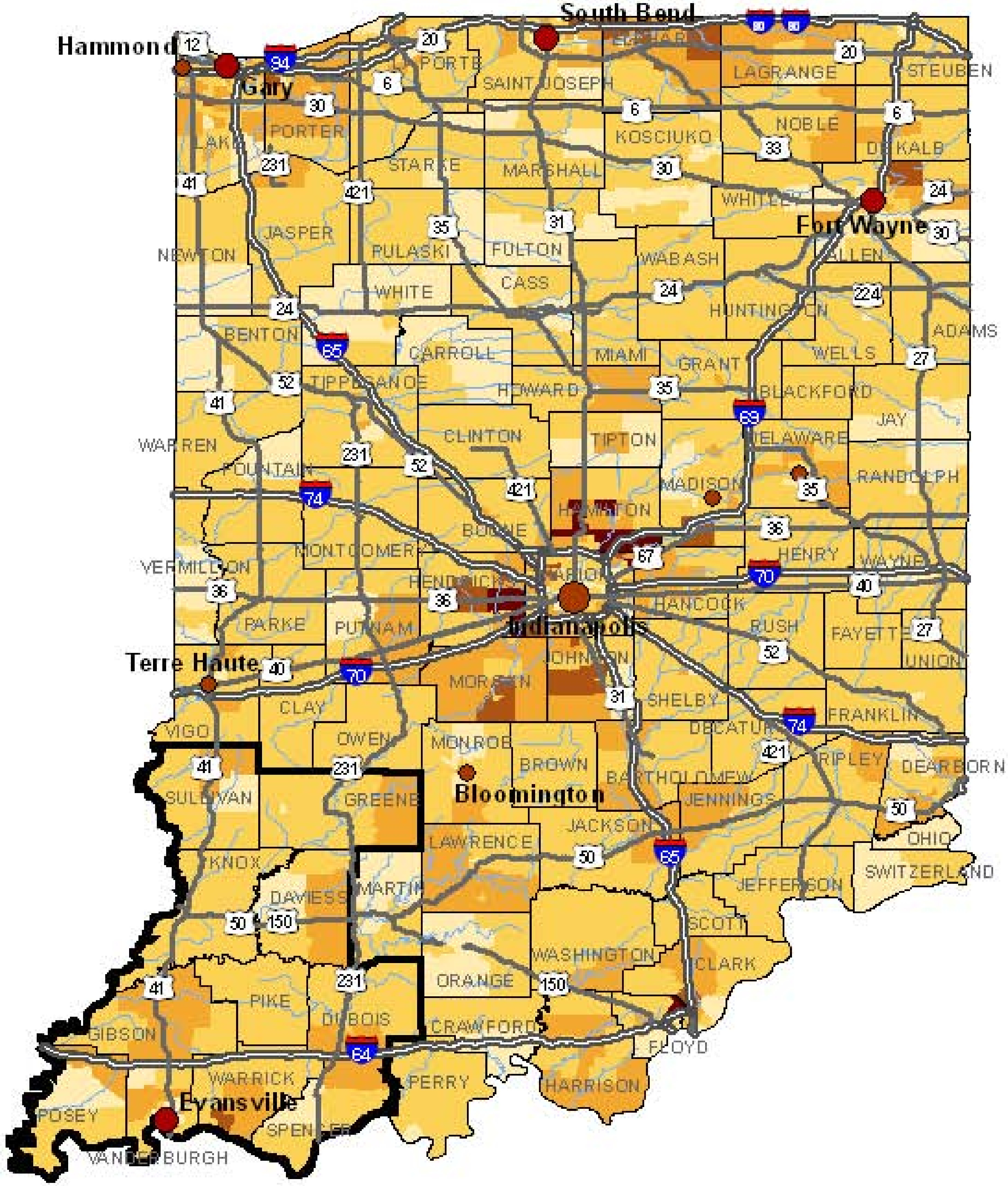
Total Population (2000) - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana
Critical Counties (11)

County	Population
Daviess	44,373
Dubois	62,739
Gibson	50,515
Greene	48,832
Knox	69,133
Pike	28,529
Posey	27,061
Spencer	31,088
Sullivan	33,573
Vanderburgh	171,922
Warrick	55,182

Legend

Total Population
Year 2000 (HAZUS)

- 0 - 3,000
- 3,001 - 6,000
- 6,001 - 90,00
- 9,001 - 12,000
- 12,001 - 17,734

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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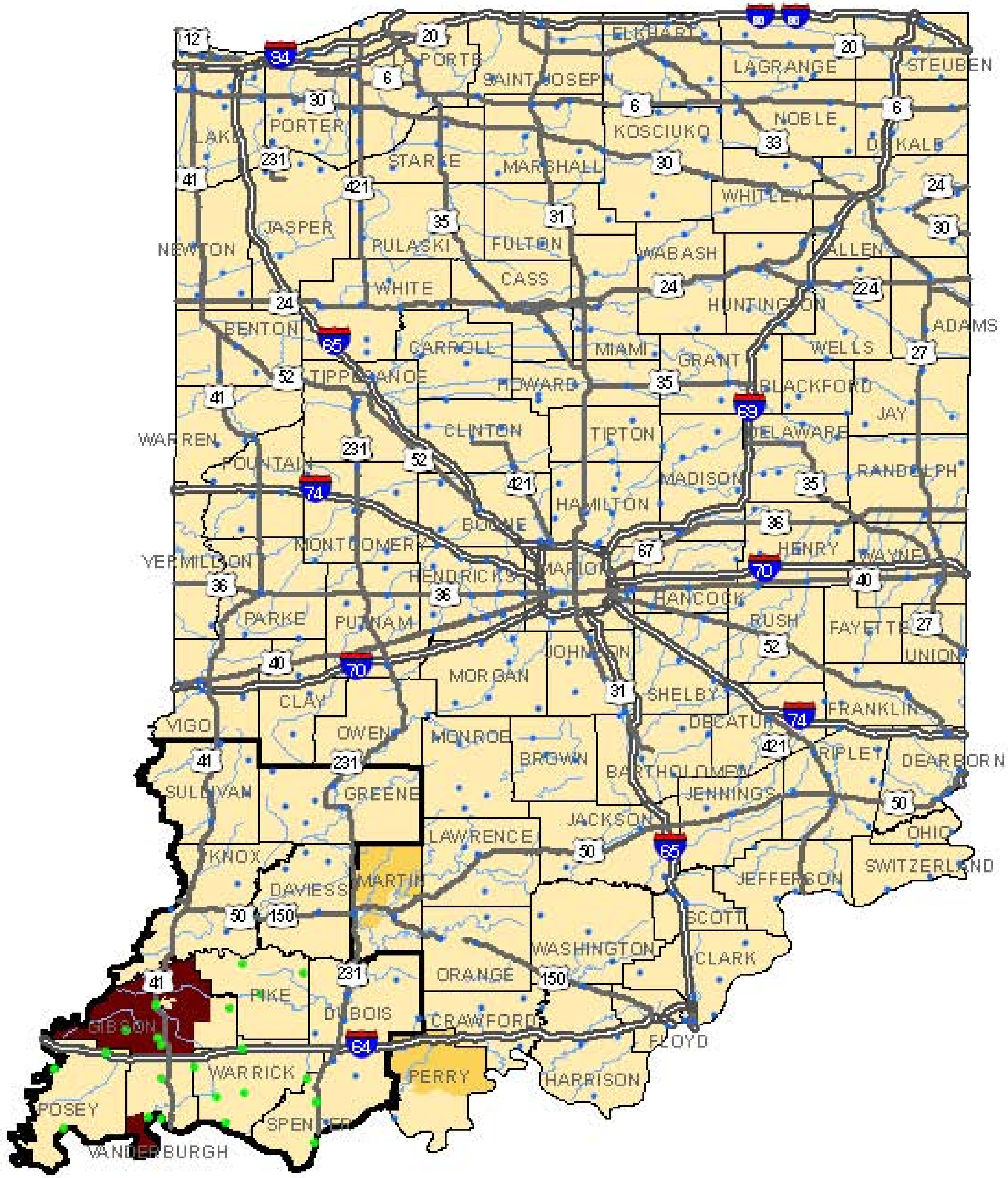
Theresa Jefferson, Principal Investigator

Waste Water Facilities Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	5	0	0
Dubois	6	0	0
Gibson	5	0	0
Greene	6	0	0
Knox	3	0	0
Pike	3	0	0
Posey	3	0	0
Spencer	7	0	0
Sullivan	6	0	0
Vanderburgh	3	0	0
Warrick	5	0	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Waste Water Pipeline Damage

No. of Leaks

- 0 - 2
- 2 - 5
- 5 - 10
- 10 - 15
- 15 - 29

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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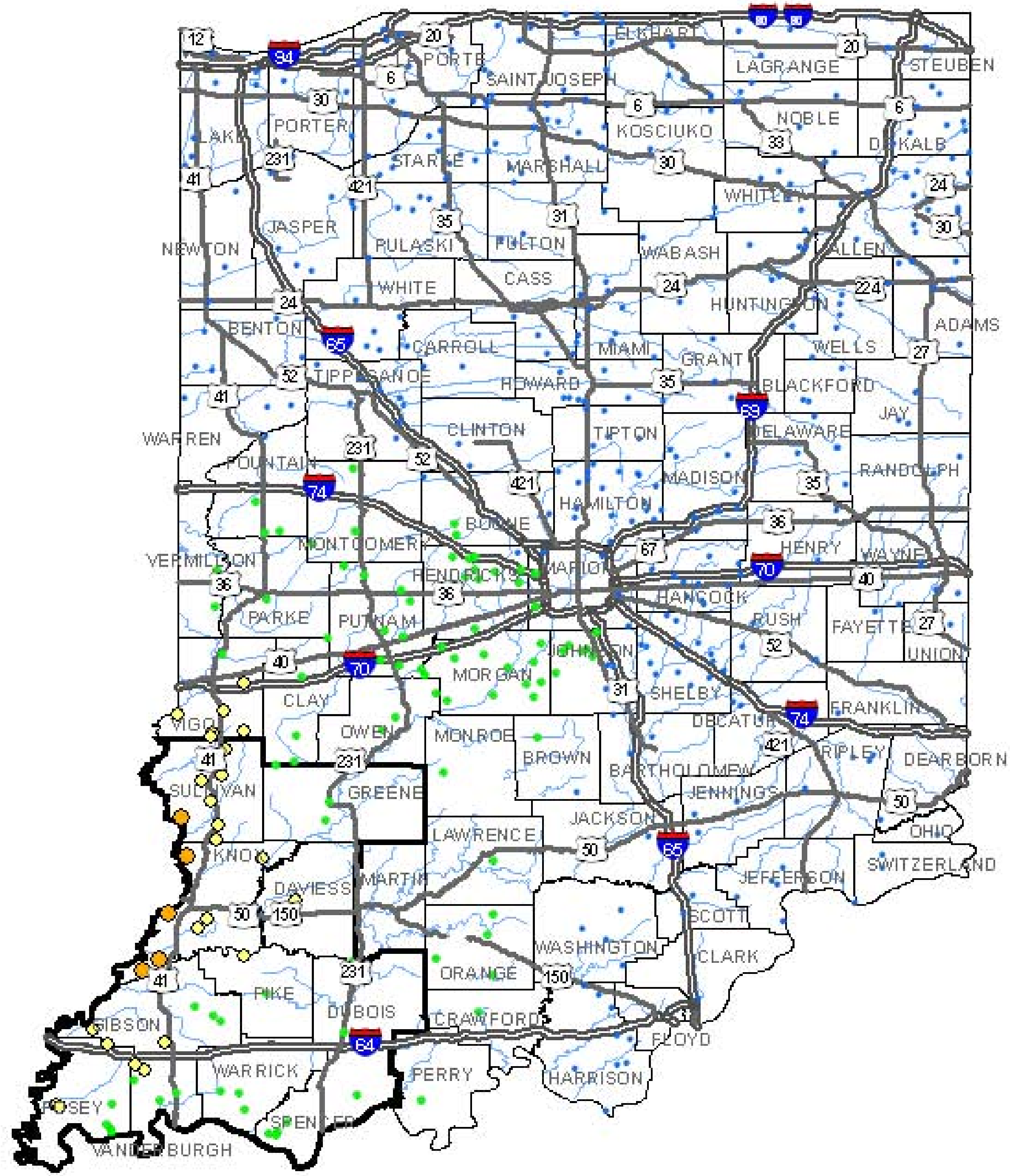
Airport Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	1	0	0
Dubois	2	0	0
Gibson	7	0	0
Greene	3	0	0
Knox	8	4	0
Pike	2	0	0
Posey	6	0	0
Spencer	5	0	0
Sullivan	7	1	0
Vanderburgh	5	0	0
Warrick	3	0	0

Legend

Airport Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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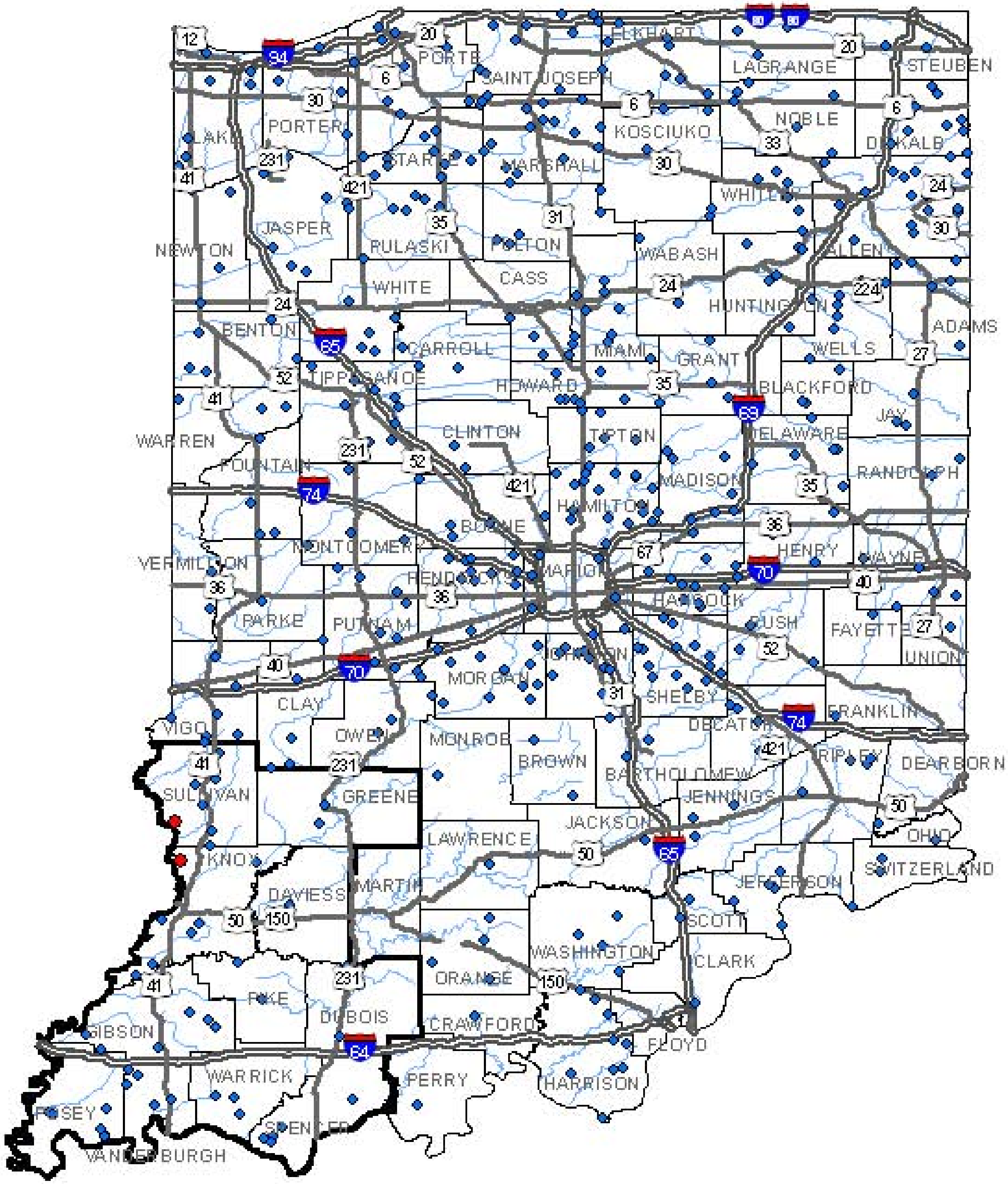
Airport Functionality at Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	1	1
Dubois	2	2
Gibson	7	7
Greene	3	3
Knox	7	8
Pike	2	2
Posey	6	6
Spencer	5	5
Sullivan	6	7
Vanderburgh	5	5
Warrick	3	3

Legend

Airport Functionality

Day 1

- Not Functional
- Functional

Interstates

US Routes

Critical Counties

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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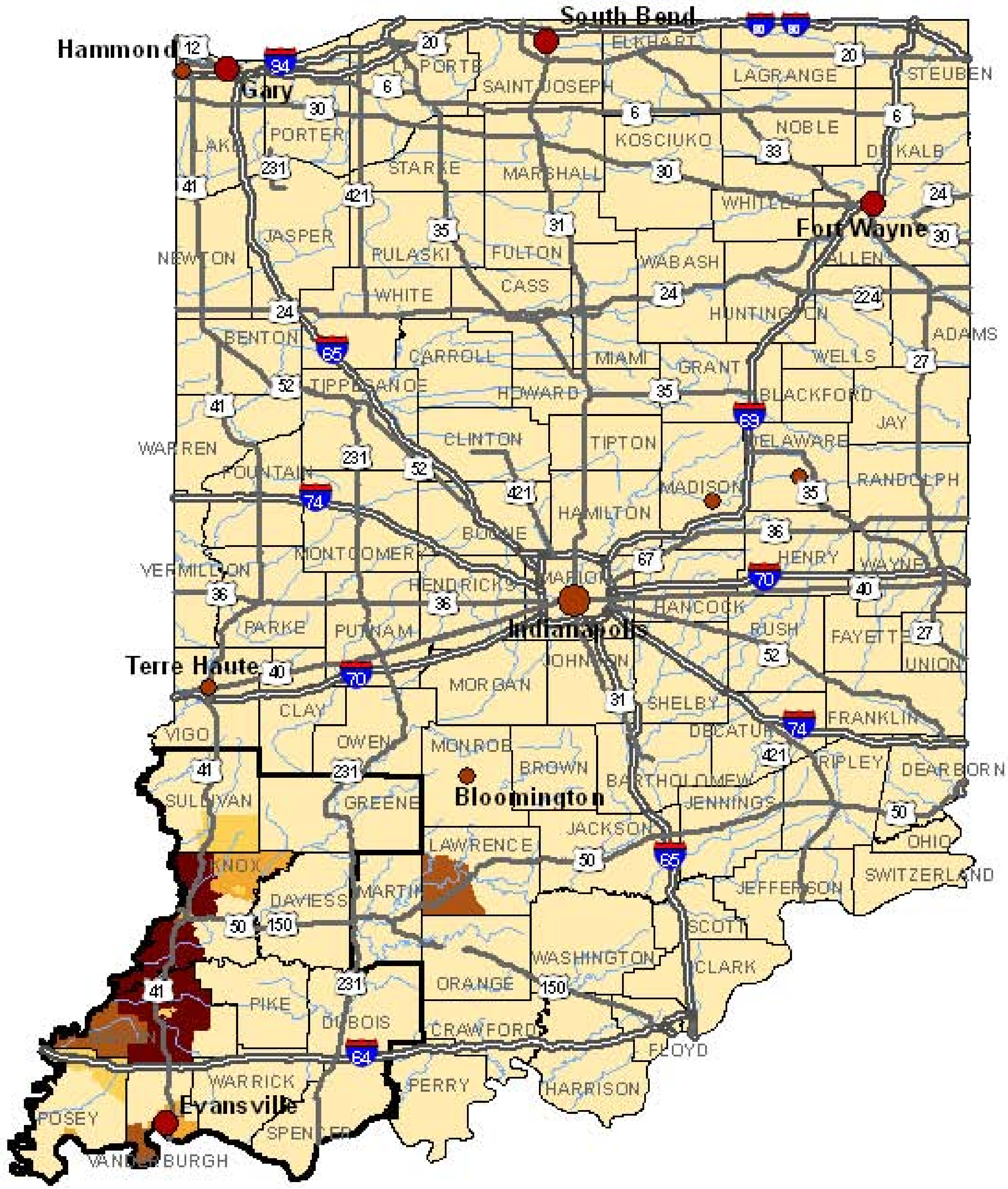
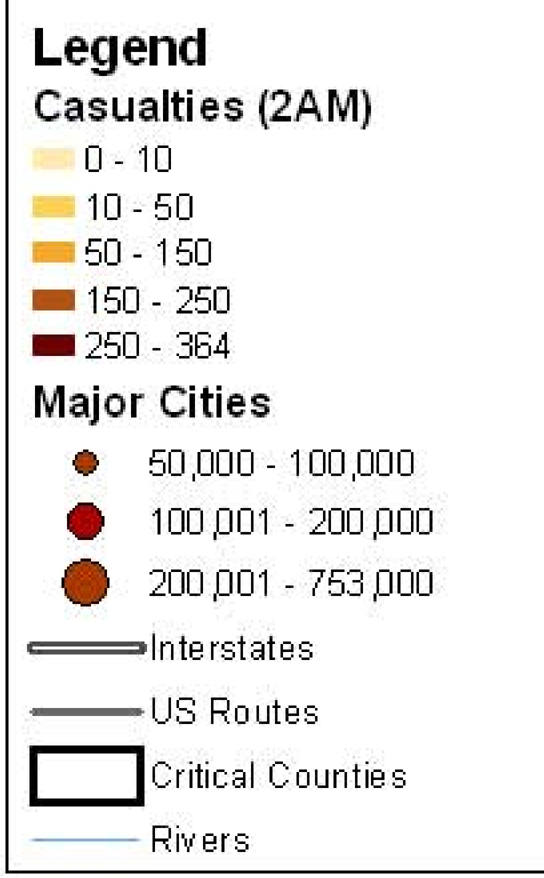
Worst Case Casualties (2AM)- Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Daviess	26	1	27
Dubois	10	0	10
Gibson	883	36	919
Greene	0	0	0
Knox	1,330	61	1,392
Pike	2	0	2
Posey	195	8	203
Spencer	0	0	0
Sullivan	38	1	39
Vanderburgh	2,808	129	2,937
Warrick	0	0	1



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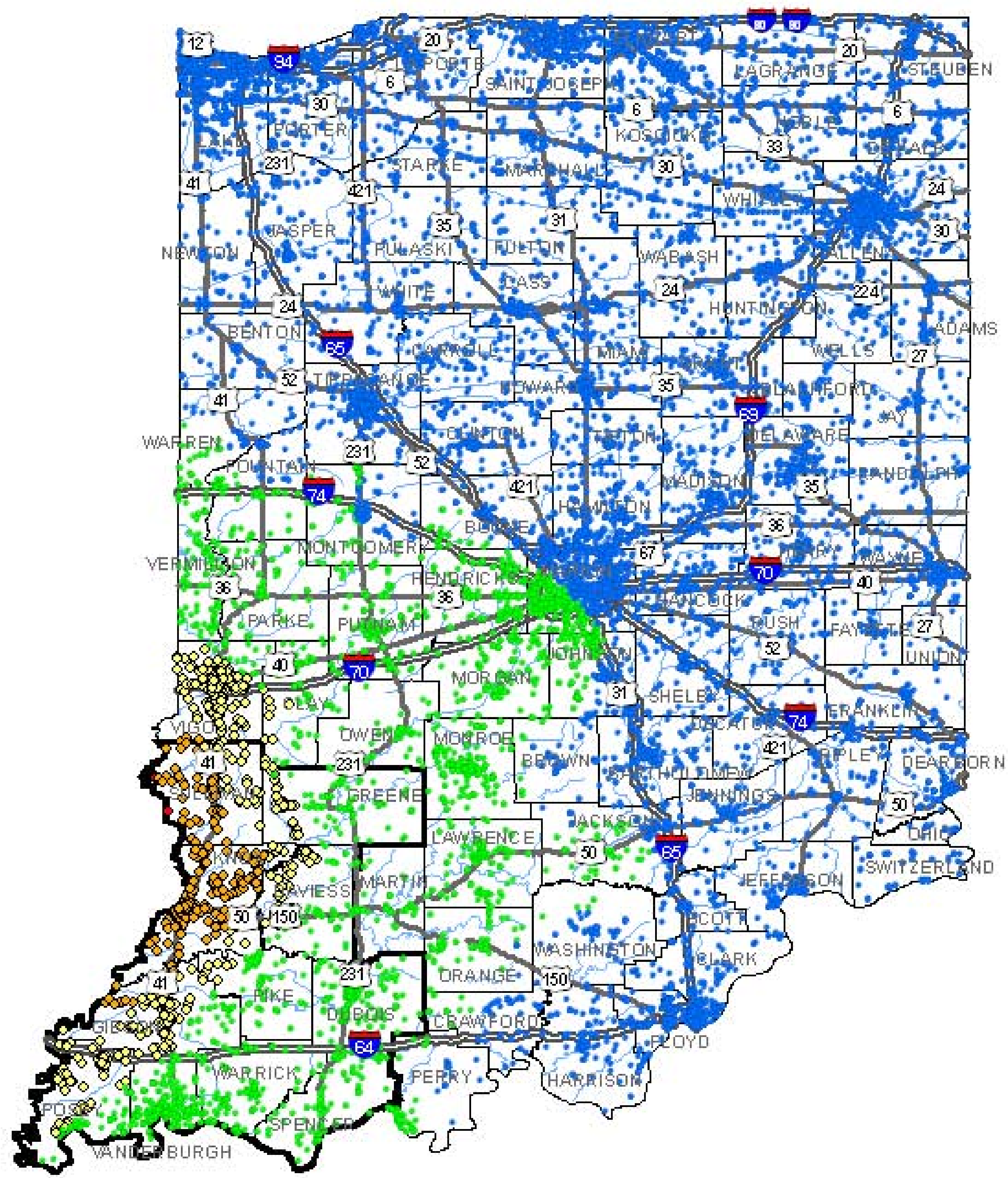
Communication Facility Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	167	0	0
Dubois	274	0	0
Gibson	235	35	0
Greene	155	0	0
Knox	301	280	0
Pike	127	0	0
Posey	200	0	0
Spencer	127	0	0
Sullivan	184	117	0
Vanderburgh	507	0	0
Warrick	213	0	0

Legend

Communication Facility Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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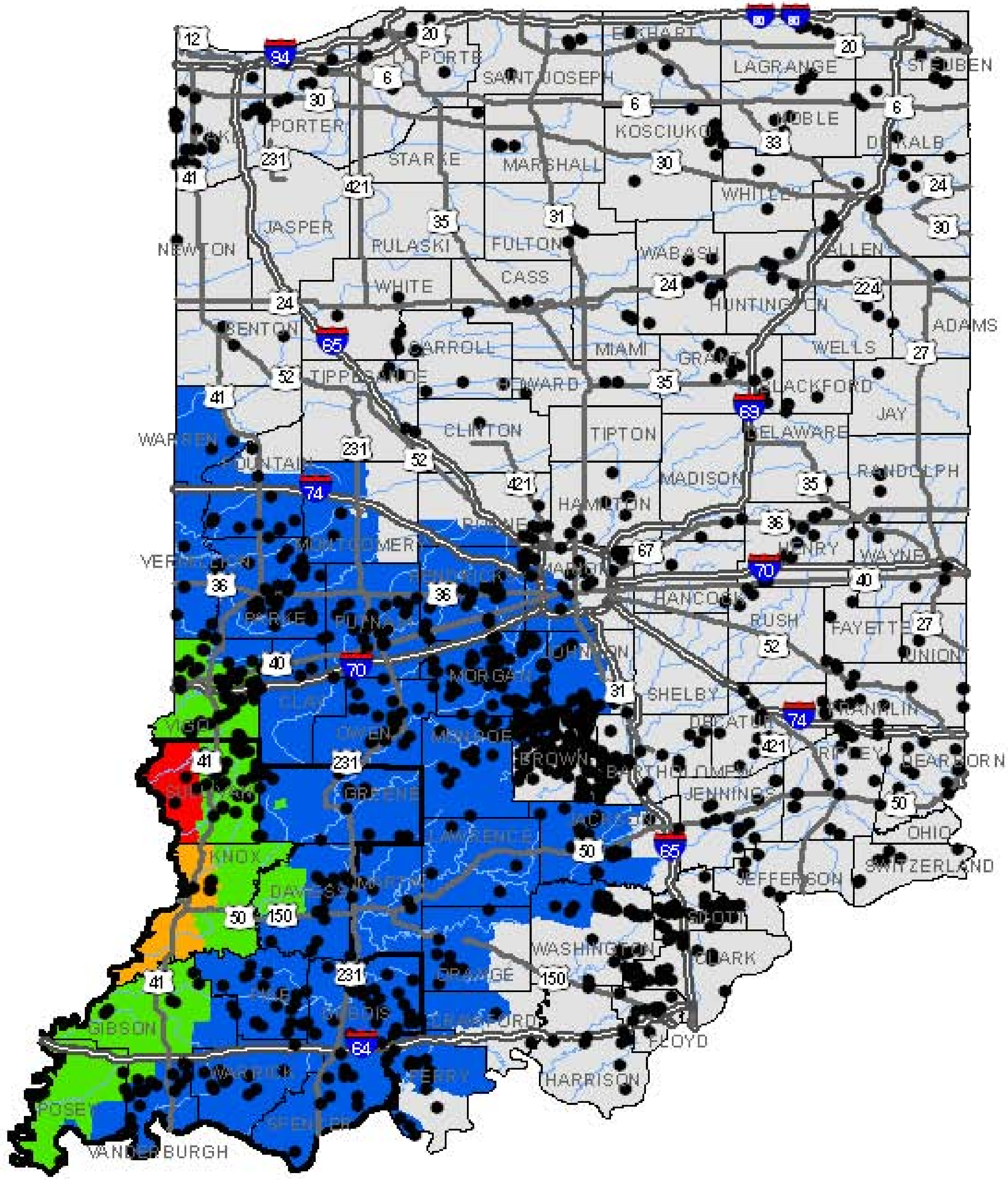
Dams - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Facilities
Daviess	14
Dubois	34
Gibson	8
Greene	19
Knox	6
Pike	25
Posey	5
Spencer	11
Sullivan	31
Vanderburgh	22
Warrick	15

Legend

- Dams

MMI

- <VI
- VI
- VII
- VIII
- IX

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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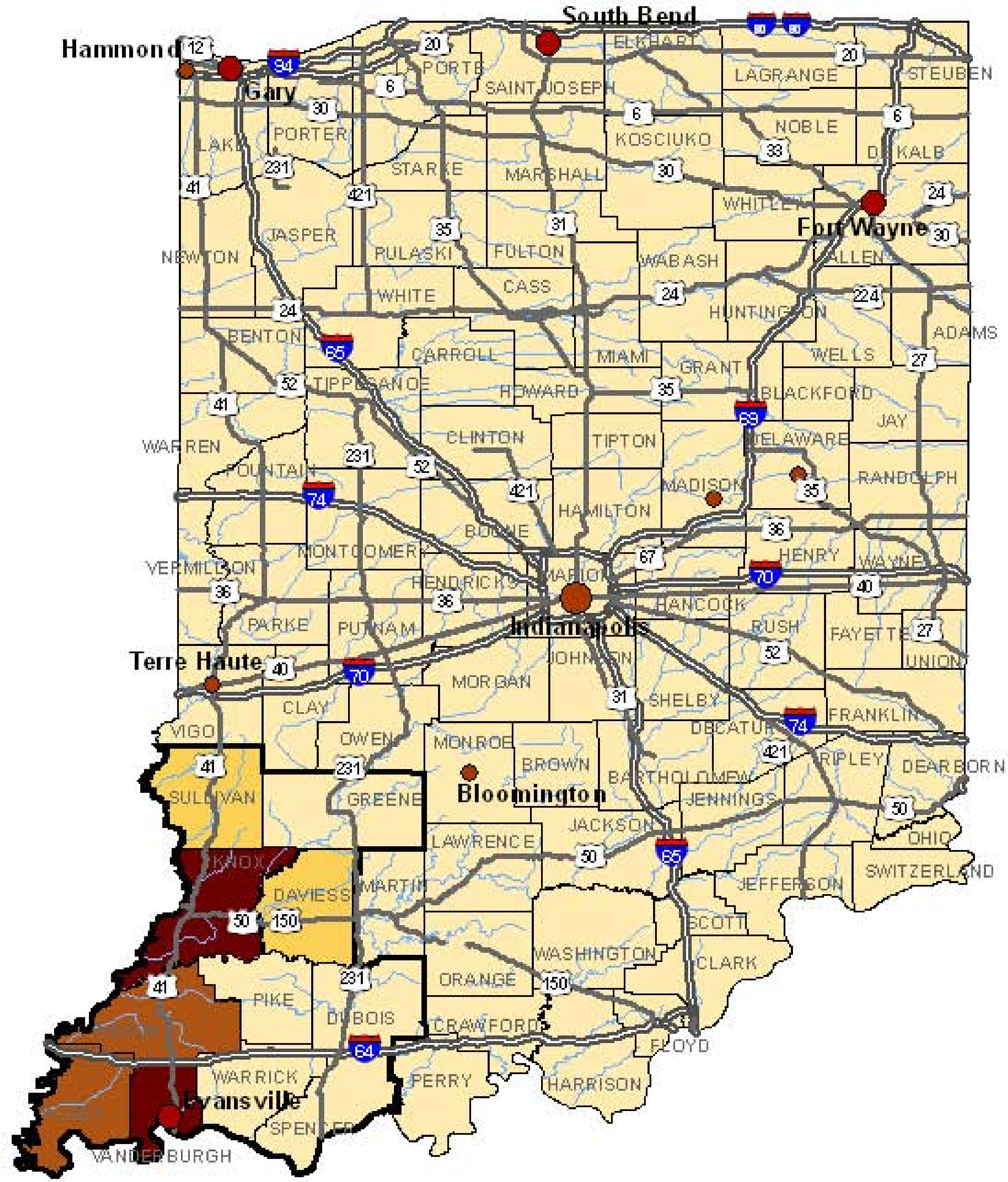
Displaced Population - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Displaced Residences	Estimate of Displaced Population
Daviess	40	109
Dubois	1	3
Gibson	1,827	4,621
Greene	0	0
Knox	2,633	6,646
Pike	0	0
Posey	388	1,030
Spencer	0	0
Sullivan	31	86
Vanderburgh	5,844	14,226
Warrick	0	0

Legend

Displaced Population

- 0 - 5
- 6 - 200
- 201 - 1,000
- 1,001 - 5,000
- 5,001 - 14,226

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

Interstates

US Routes

Critical Counties

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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Electric Power Facility Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008

State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Dubois	4	0	0
Gibson	8	7	0
Greene	7	0	0
Knox	15	8	0
Pike	14	0	0
Posey	7	0	0
Spencer	8	0	0
Sullivan	8	8	0
Vanderburgh	14	0	0
Warrick	12	0	0
Daviess	0	0	0

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Electric Transmission Lines
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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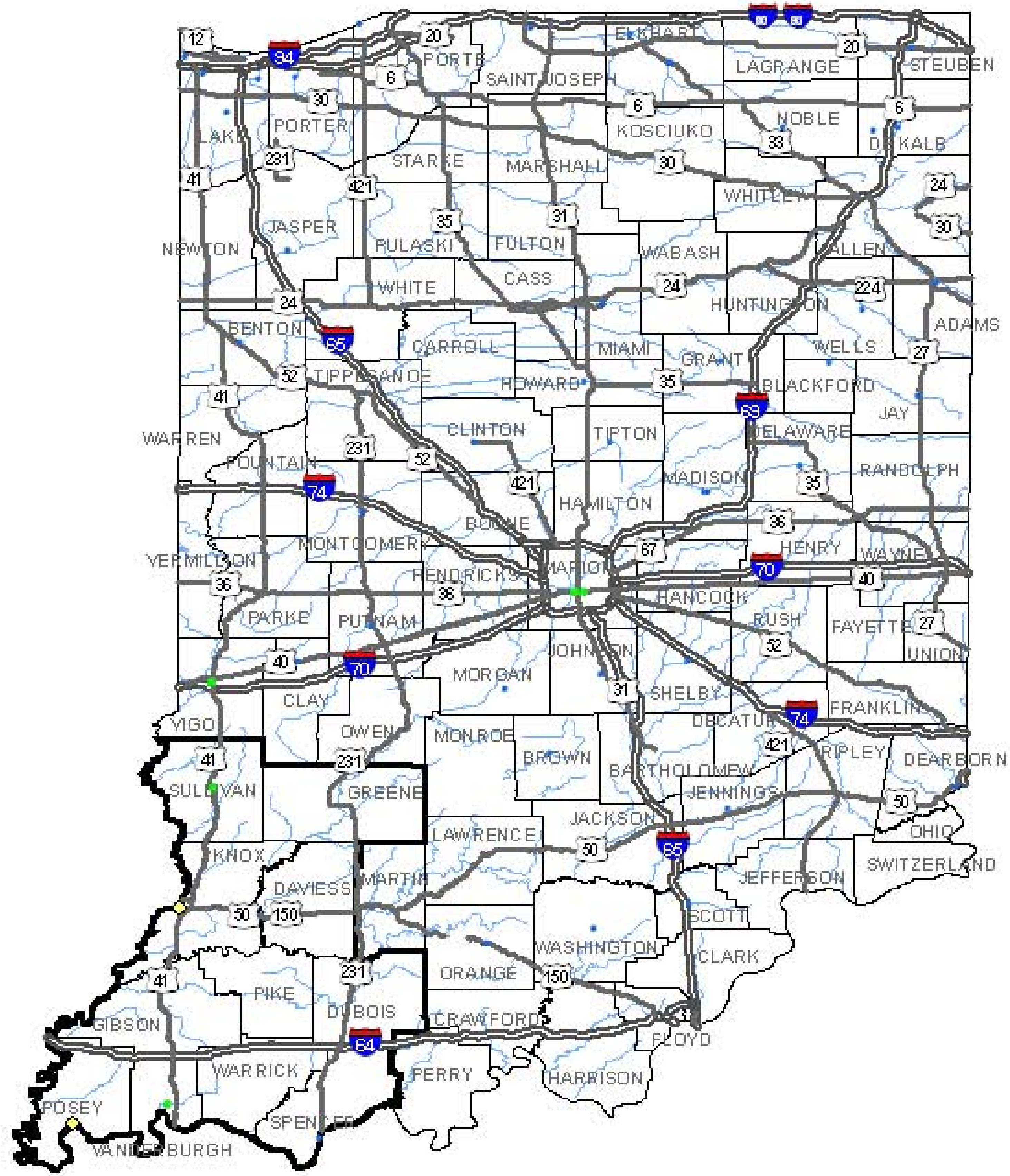
Emergency Oper. Center Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Knox	1	0	0
Posey	1	0	0
Spencer	1	0	0
Sullivan	2	0	0
Vanderburgh	1	0	0
Daviess	0	0	0
Dubois	0	0	0
Gibson	0	0	0
Greene	0	0	0
Pike	0	0	0
Warrick	0	0	0

Legend

Emergency Oper. Center Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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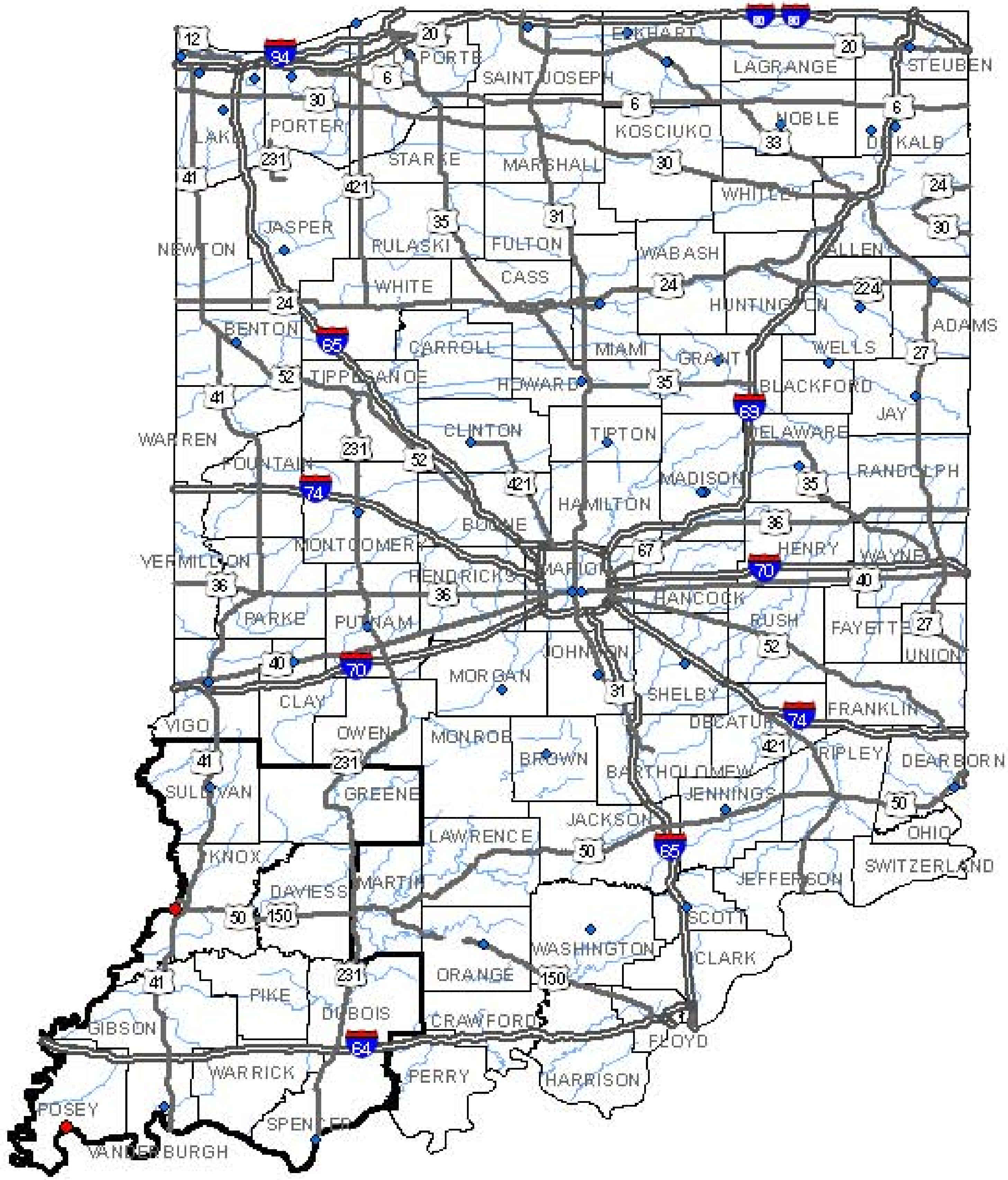
EOC Functionality at Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Knox	0	1
Posey	0	1
Spencer	1	1
Sullivan	2	2
Vanderburgh	1	1
Daviess	0	0
Dubois	0	0
Gibson	0	0
Greene	0	0
Pike	0	0
Warrick	0	0

Legend

Emergency Operation Center Functionality at Day 1

- Not Functional
- Functional

Interstates

US Routes

Critical Counties

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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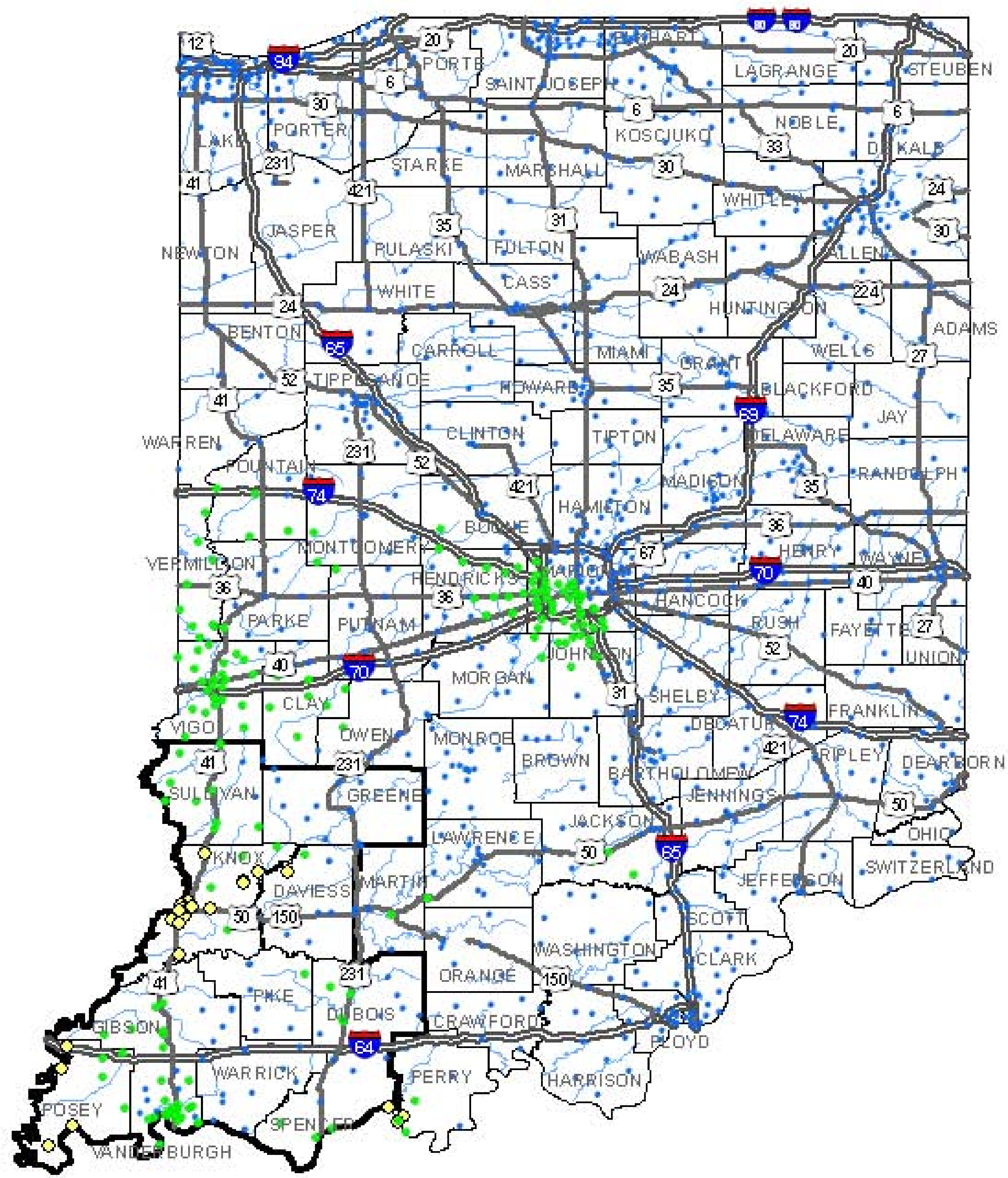
Fire Station Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	12	0	0
Dubois	14	0	0
Gibson	13	0	0
Greene	14	0	0
Knox	19	0	0
Pike	8	0	0
Posey	10	0	0
Spencer	7	0	0
Sullivan	12	0	0
Vanderburgh	26	0	0
Warrick	11	0	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

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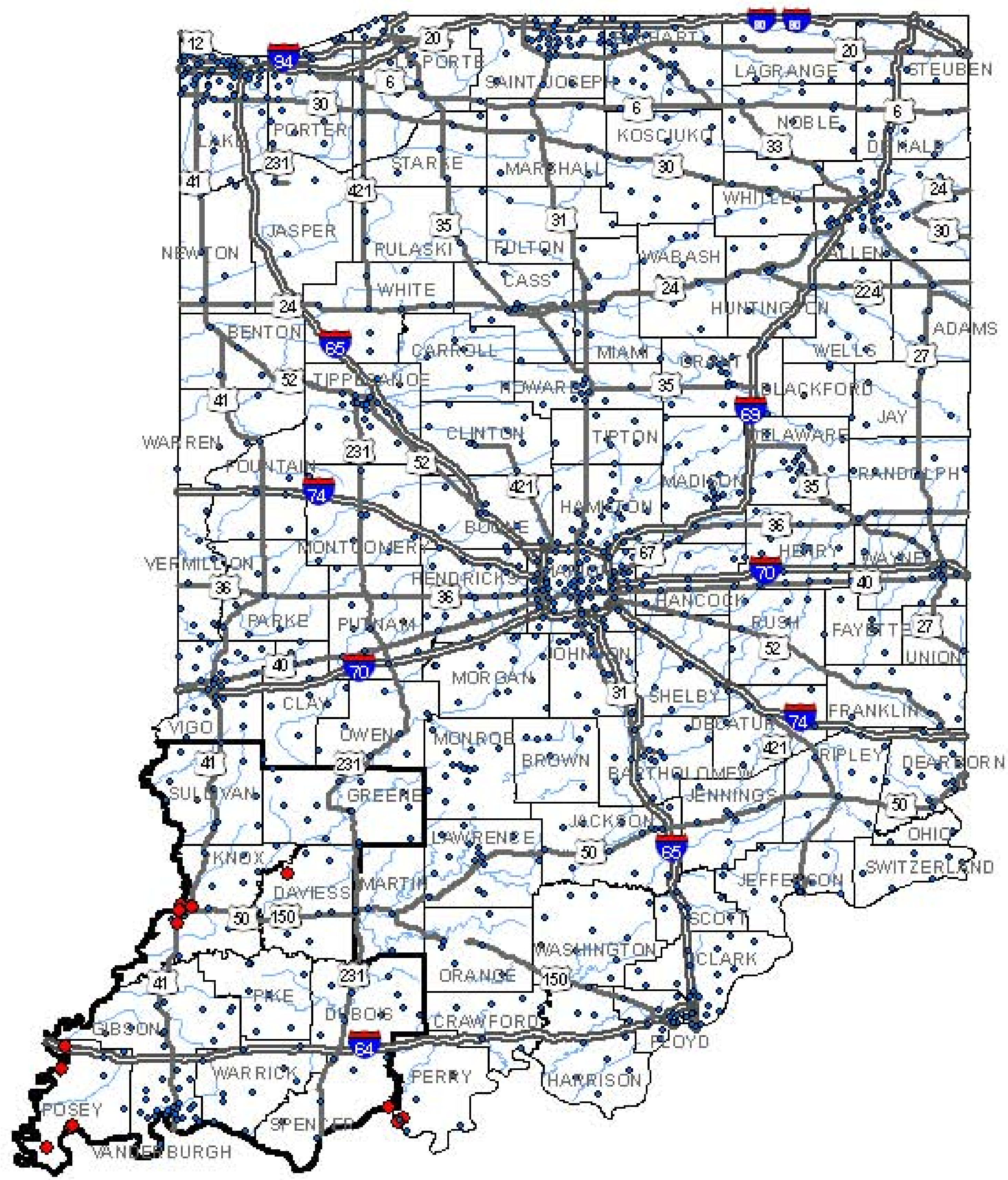
Fire Station Functionality at Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	11	12
Dubois	14	14
Gibson	13	13
Greene	14	14
Knox	14	19
Pike	8	8
Posey	4	10
Spencer	7	7
Sullivan	12	12
Vanderburgh	26	26
Warrick	11	11

Legend

Fire Station Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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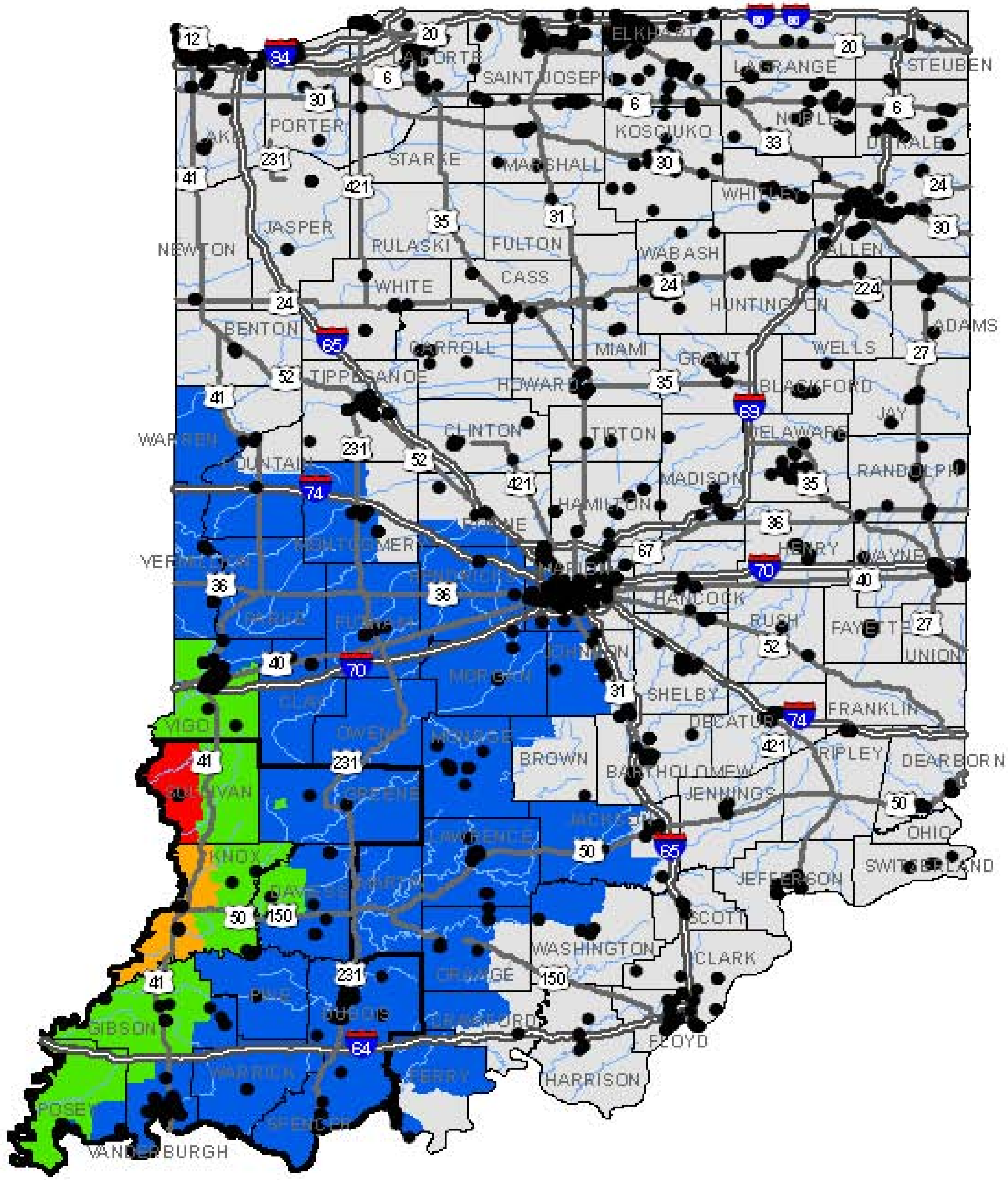
Hazardous Materials Facilities - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Facilities
Daviess	30
Dubois	62
Gibson	45
Greene	4
Knox	20
Pike	27
Posey	62
Spencer	24
Sullivan	16
Vanderburgh	73
Warrick	56

Legend

- Hazmat Facilities

MMI

- <VI
- VI
- VII
- VIII
- IX

Interstates

US Routes

Critical Counties

Rivers

0 10 20 40 60

Miles

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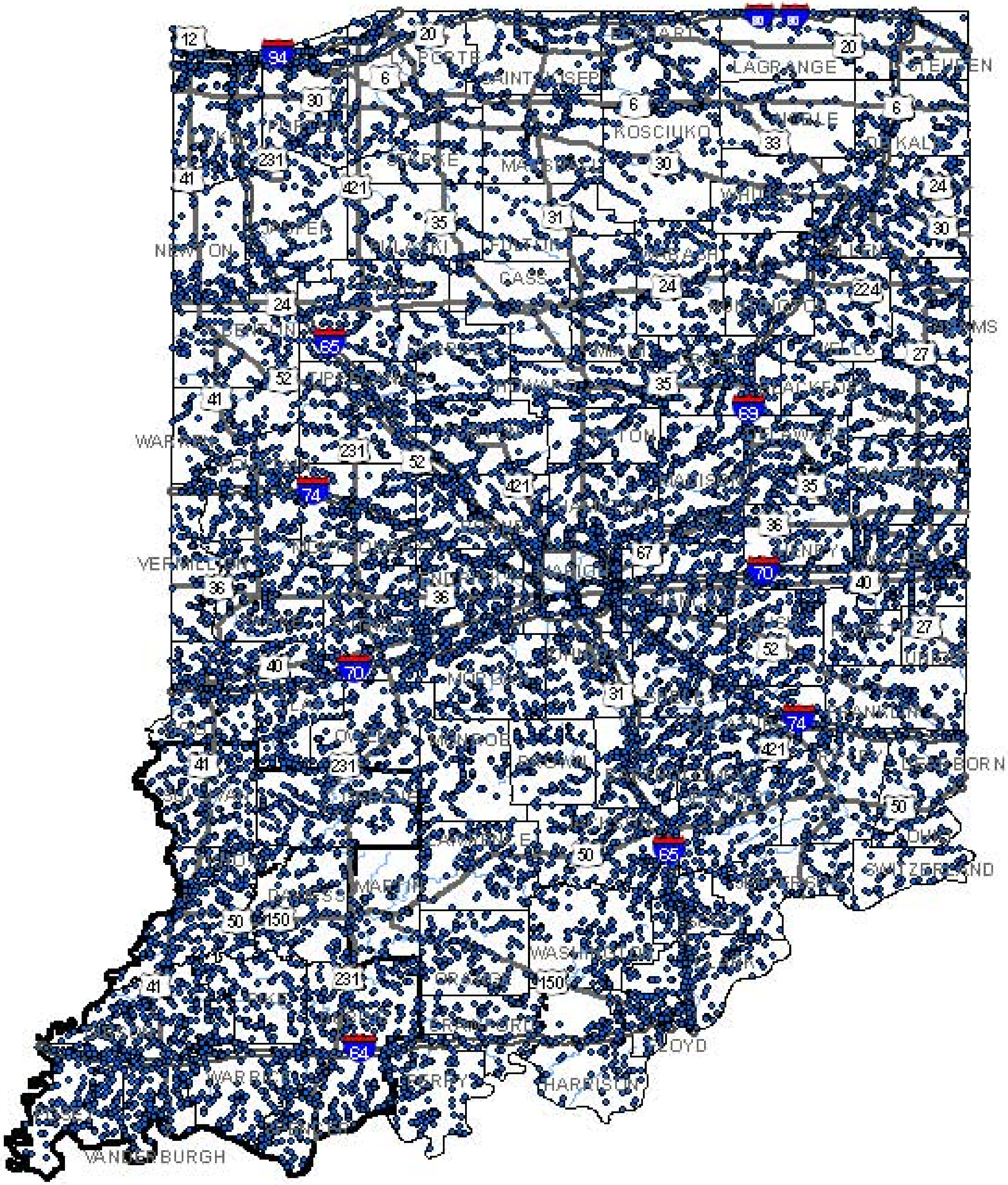
Highway Bridge Functionality:Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	136	136
Dubois	194	194
Gibson	296	296
Greene	201	201
Knox	288	288
Pike	136	136
Posey	191	191
Spencer	212	212
Sullivan	204	204
Vanderburgh	189	189
Warrick	173	173

Legend

Highway Bridge Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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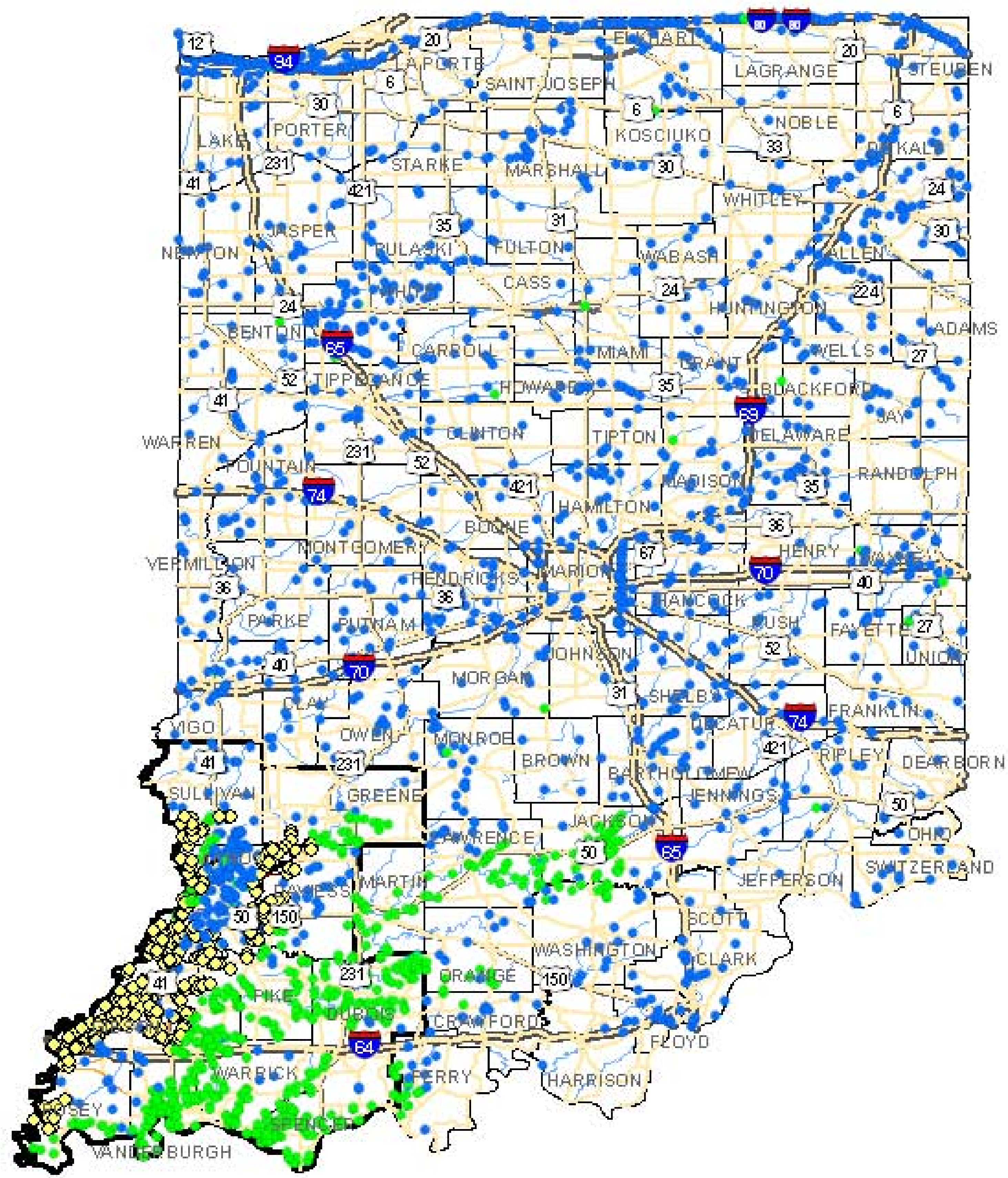
Highway Bridge & Segment Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	136	0	0
Dubois	194	0	0
Gibson	296	0	0
Greene	201	0	0
Knox	288	0	0
Pike	136	0	0
Posey	191	0	0
Spencer	212	0	0
Sullivan	204	0	0
Vanderburgh	189	0	0
Warrick	173	0	0

Legend

Highway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Highway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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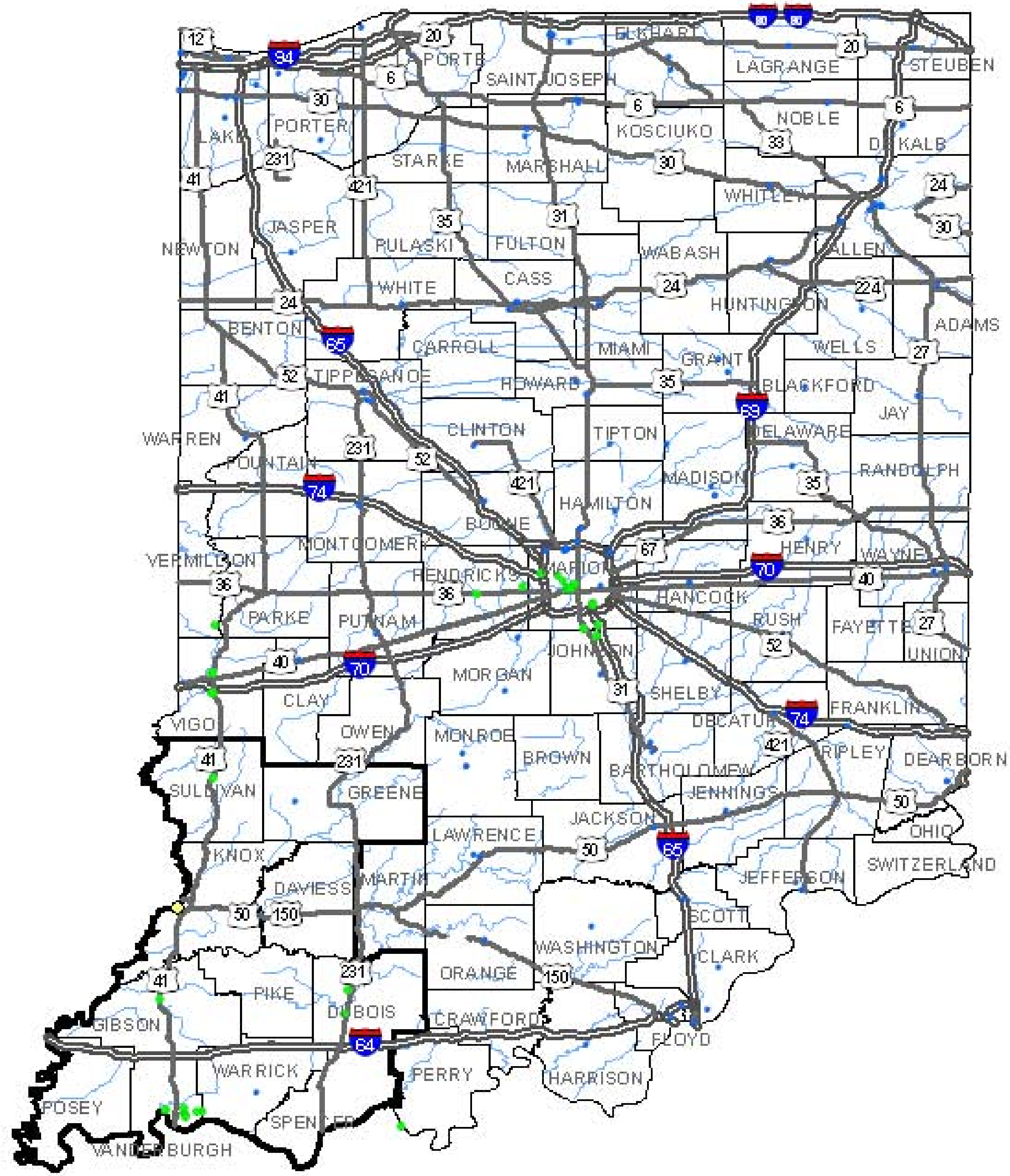
Hospital Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	1	0	0
Dubois	2	0	0
Gibson	1	0	0
Greene	1	0	0
Knox	1	0	0
Sullivan	1	0	0
Vanderburgh	7	0	0
Warrick	2	0	0
Pike	0	0	0
Posey	0	0	0
Spencer	0	0	0

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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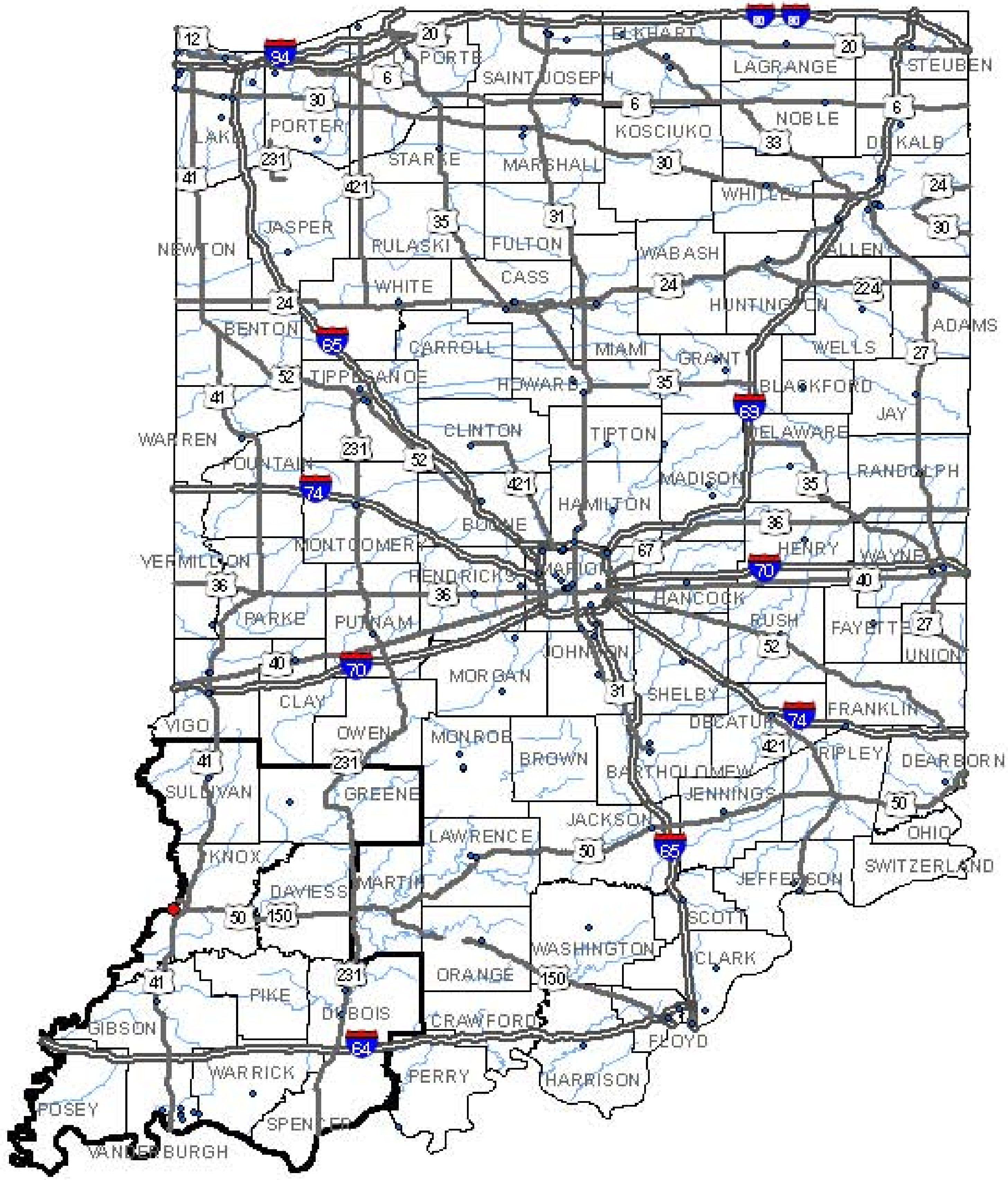
Hospital Functionality at Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	1	1
Dubois	2	2
Gibson	1	1
Greene	1	1
Knox	0	1
Sullivan	1	1
Vanderburgh	7	7
Warrick	2	2
Pike	0	0
Posey	0	0
Spencer	0	0

Legend

Hospital Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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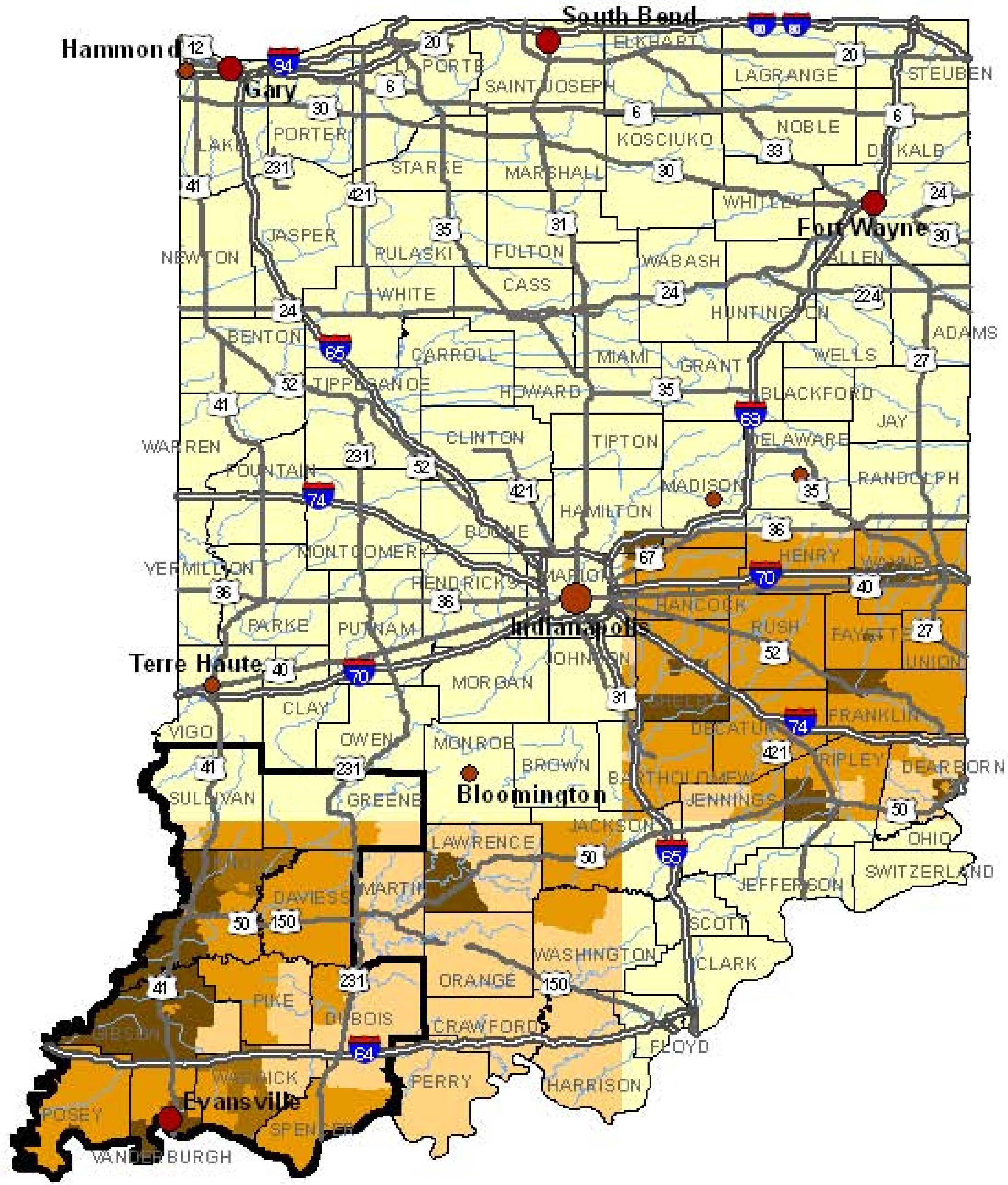
Liquefaction Susceptibility - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Minimum Susceptibility	Maximum Susceptibility
Daviess	Low	Low
Dubois	None	Low
Gibson	None	Very High
Greene	Unknown	Low
Knox	Low	Very High
Pike	None	Low
Posey	Low	Very High
Spencer	None	Low
Sullivan	Unknown	Low
Vanderburgh	Low	Very High
Warrick	None	Moderate

Legend

Liquefaction Susceptibility

- Unknown
- None
- Low
- Moderate
- Very High

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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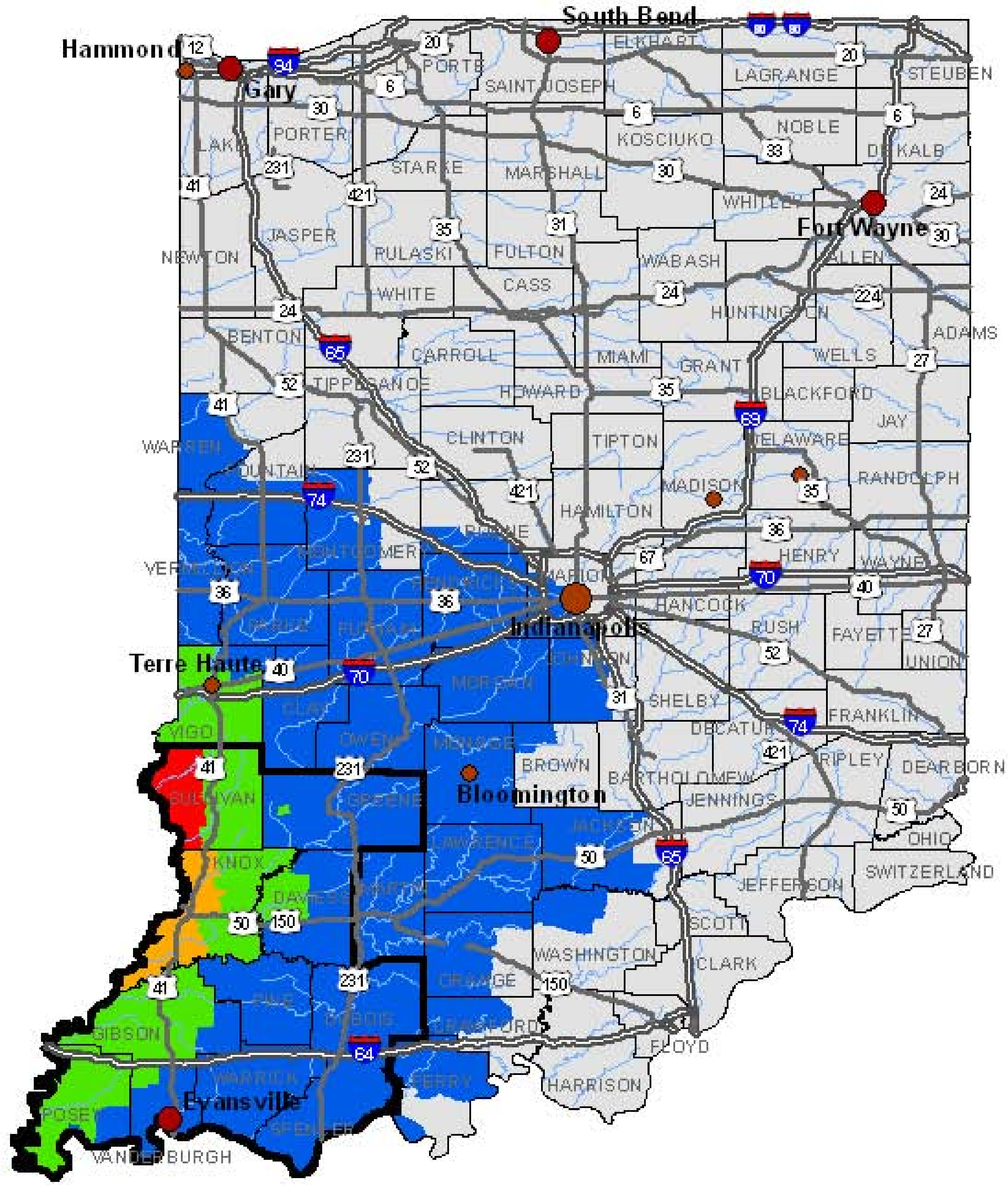
Modified Mercalli Intensity - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Max. MMI
Daviess	VII
Dubois	VI
Gibson	VII
Greene	VII
Knox	VIII
Pike	VI
Posey	VII
Spencer	VI
Sullivan	IX
Vanderburgh	VII
Warrick	VI

Legend

MMI

- <VI
- VI
- VII
- VIII
- IX

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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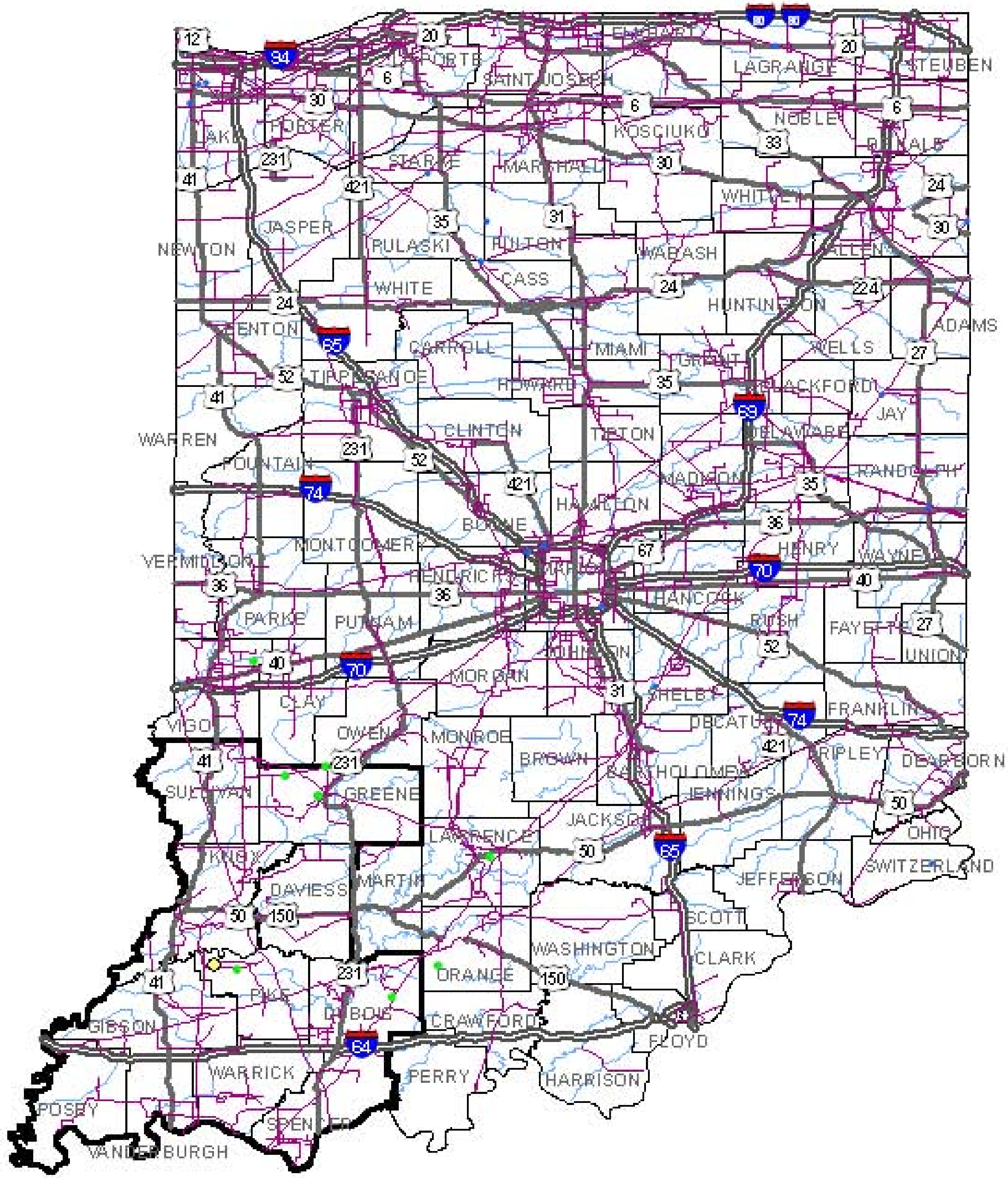
Natural Gas Facility Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Dubois	1	0	0
Greene	4	0	0
Pike	2	0	0
Daviess	0	0	0
Gibson	0	0	0
Knox	0	0	0
Posey	0	0	0
Spencer	0	0	0
Sullivan	0	0	0
Vanderburgh	0	0	0
Warrick	0	0	0

Legend

Natural Gas Facility Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Natural Gas Pipelines
Interstates
US Routes
Critical Counties
Rivers

0 10 20 40 60
Miles

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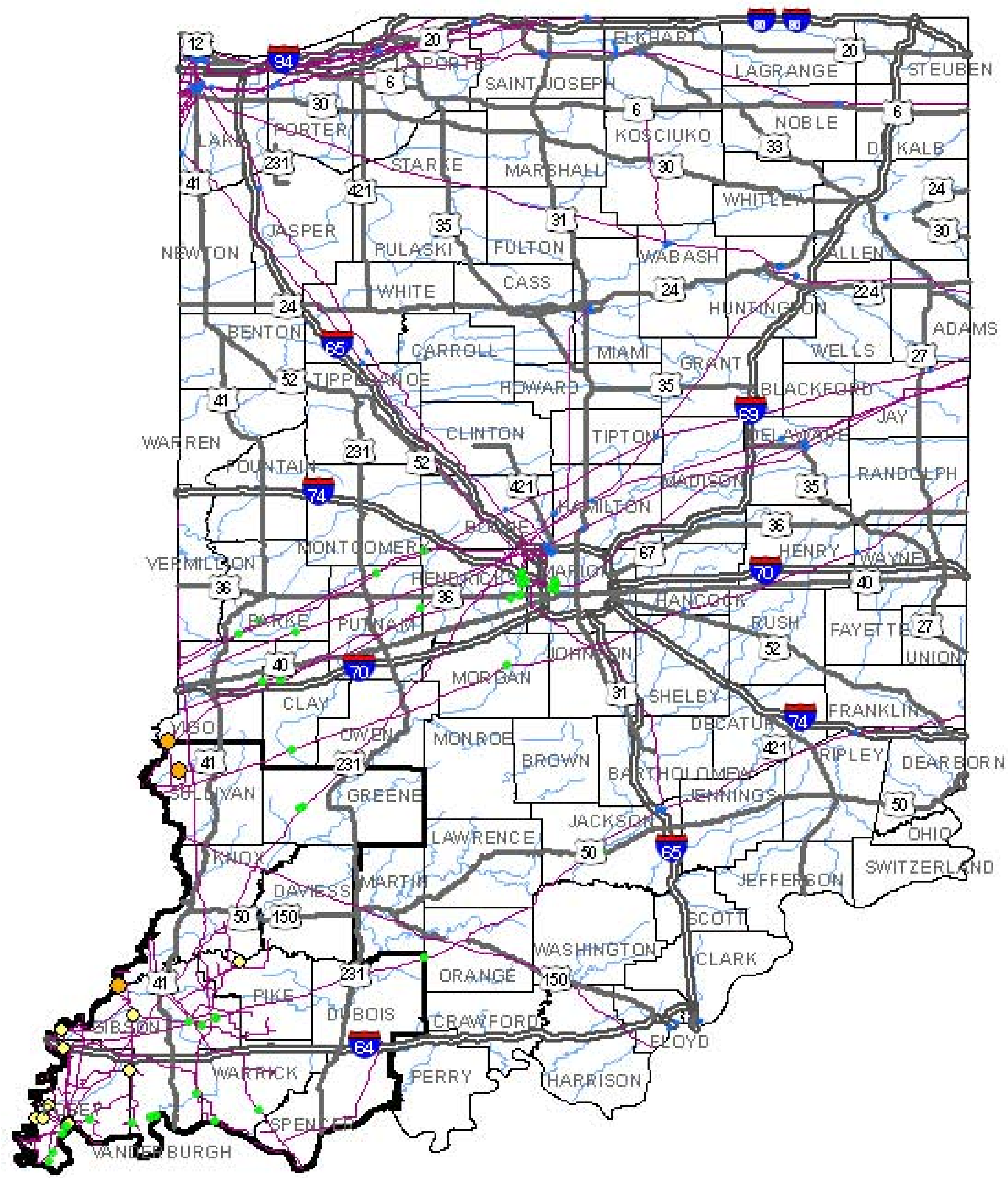
Oil Facility Damage - Wabash Valley Seismic Zone: M7.7 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Gibson	7	1	0
Greene	2	0	0
Pike	1	0	0
Posey	14	0	0
Sullivan	2	2	0
Vanderburgh	6	0	0
Warrick	3	0	0
Daviess	0	0	0
Dubois	0	0	0
Knox	0	0	0
Spencer	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Oil Pipelines
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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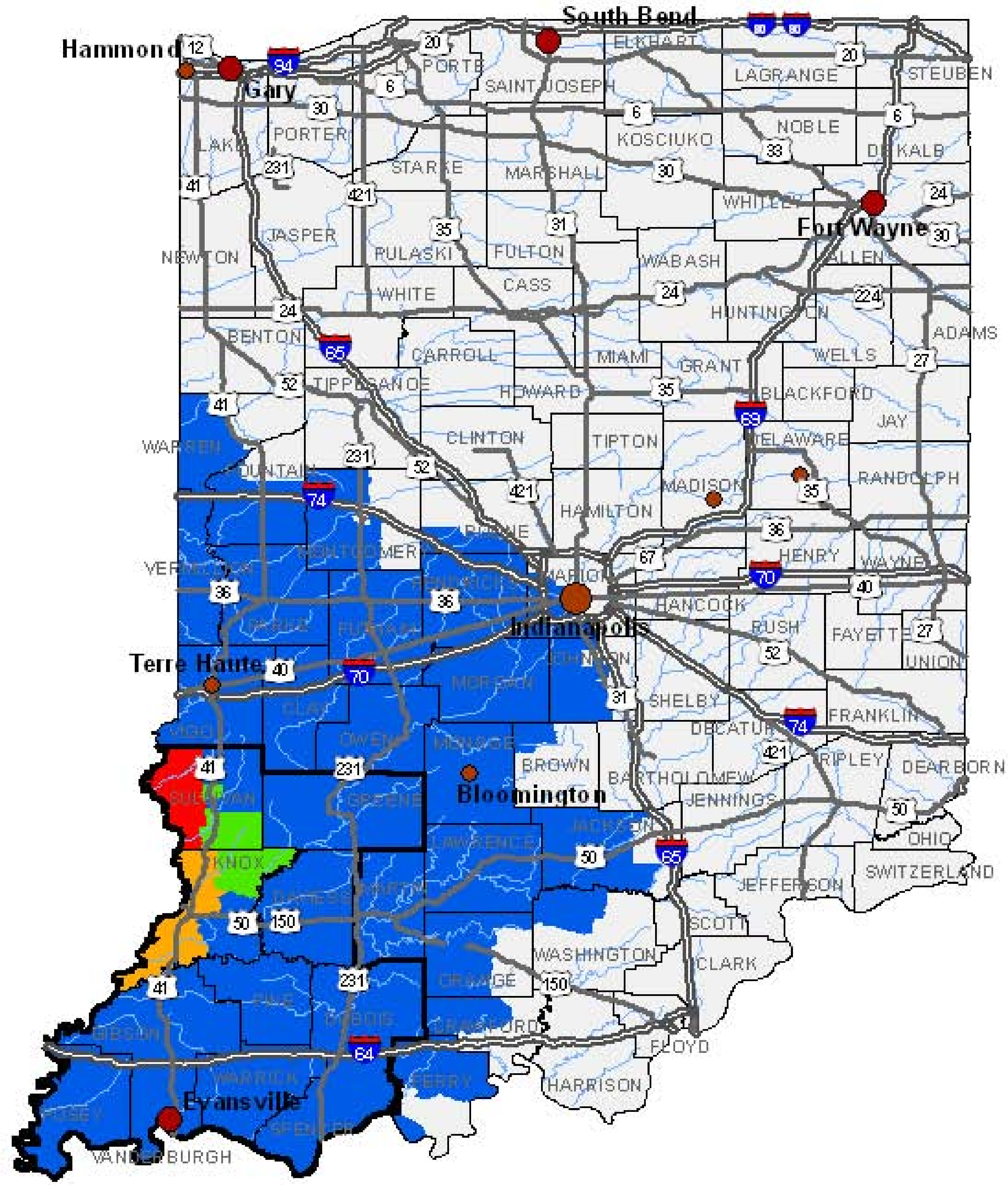
Peak Ground Acceleration - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Min. PGA	Max. PGA
Daviess	0.15	0.25
Dubois	0.15	0.15
Gibson	0.15	0.25
Greene	0.15	0.25
Knox	0.25	0.45
Pike	0.15	0.15
Posey	0.15	0.25
Spencer	0.15	0.15
Sullivan	0.25	0.55
Vanderburgh	0.15	0.25
Warrick	0.15	0.15

Legend

PGA (g)

- 0.05 - 0.15
- 0.15 - 0.25
- 0.25 - 0.35
- 0.35 - 0.45
- 0.45 - 0.55

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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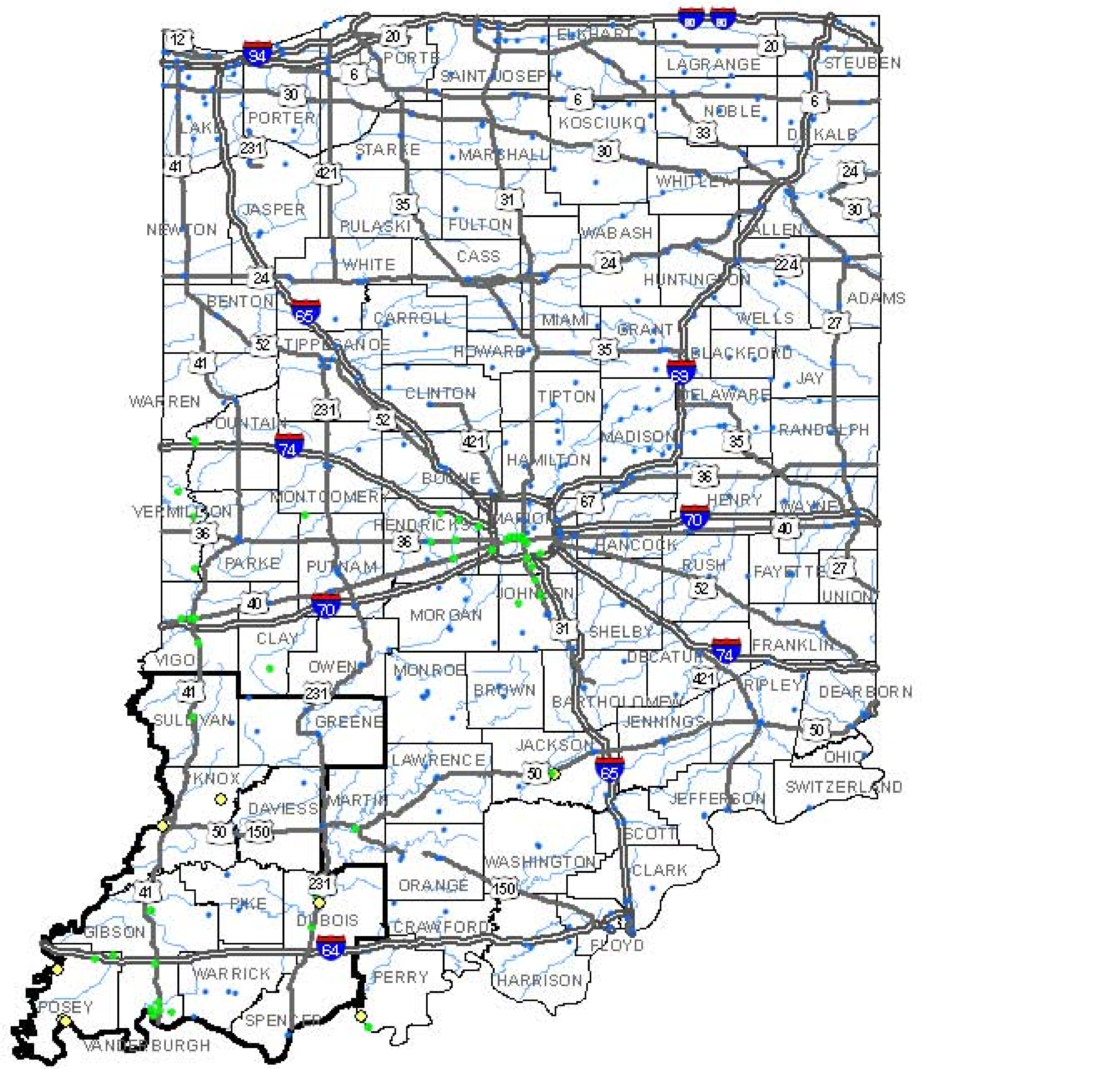
Police Station Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana
Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	3	0	0
Dubois	5	0	0
Gibson	3	0	0
Greene	5	0	0
Knox	3	0	0
Pike	4	0	0
Posey	5	0	0
Spencer	2	0	0
Sullivan	3	0	0
Vanderburgh	7	0	0
Warrick	4	0	0

Legend
Police Station Damage
At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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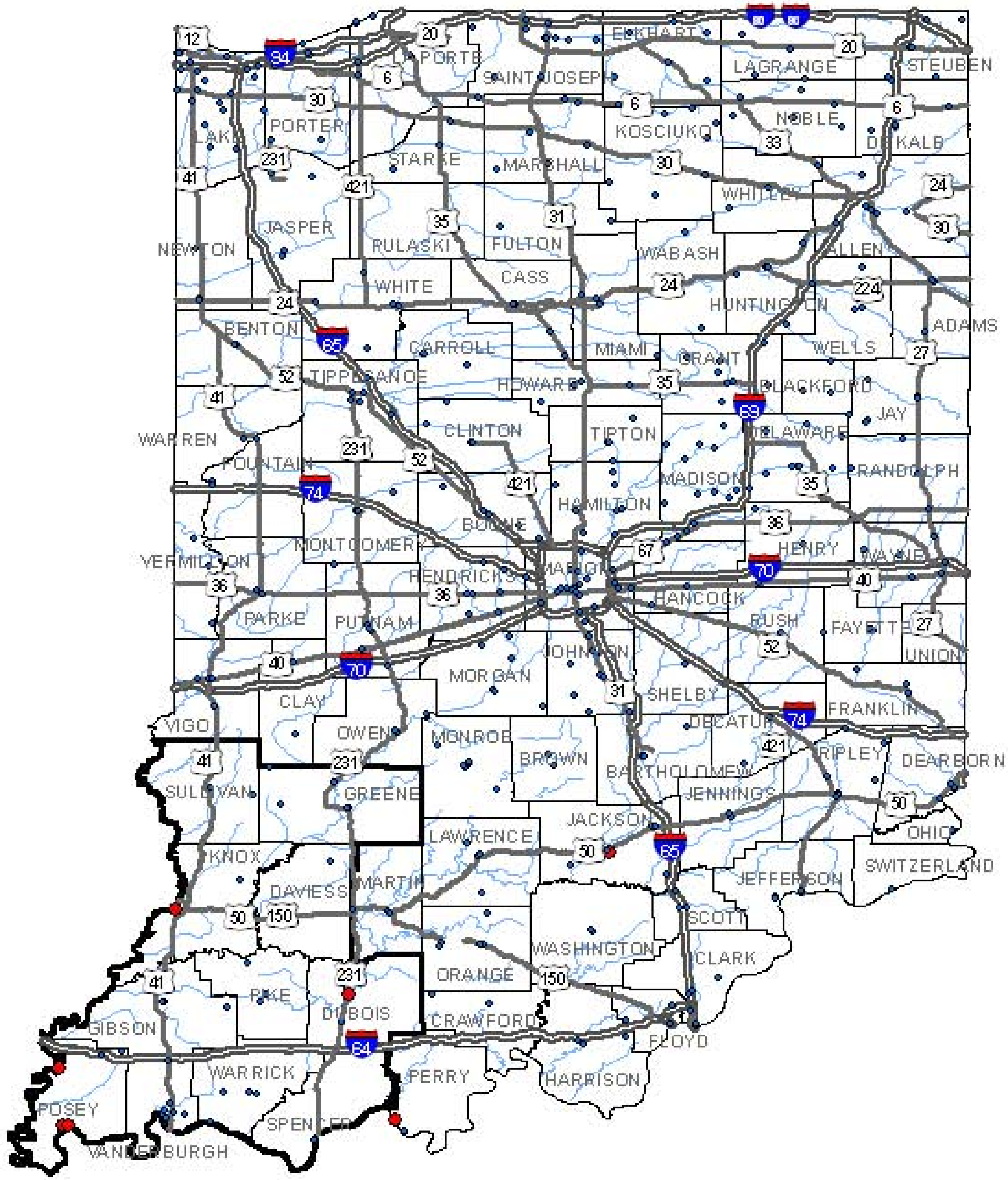
Police Station Functionality at Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	3	3
Dubois	4	5
Gibson	3	3
Greene	5	5
Knox	1	3
Pike	4	4
Posey	2	5
Spencer	2	2
Sullivan	3	3
Vanderburgh	7	7
Warrick	4	4

Legend

Police Station Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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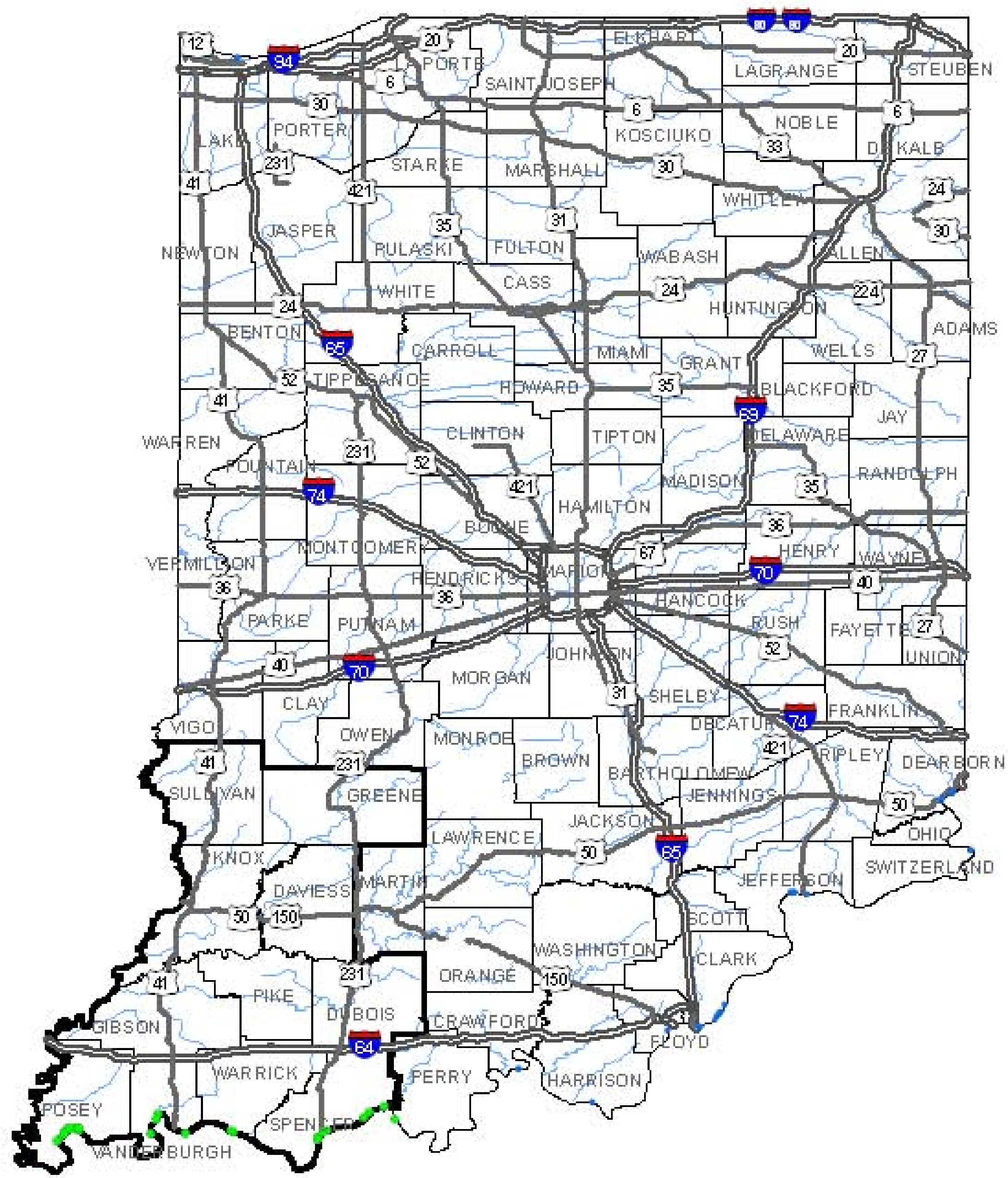
Port Facility Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Posey	20	0	0
Spencer	10	0	0
Vanderburgh	4	0	0
Warrick	2	0	0
Daviess	0	0	0
Dubois	0	0	0
Gibson	0	0	0
Greene	0	0	0
Knox	0	0	0
Pike	0	0	0
Sullivan	0	0	0

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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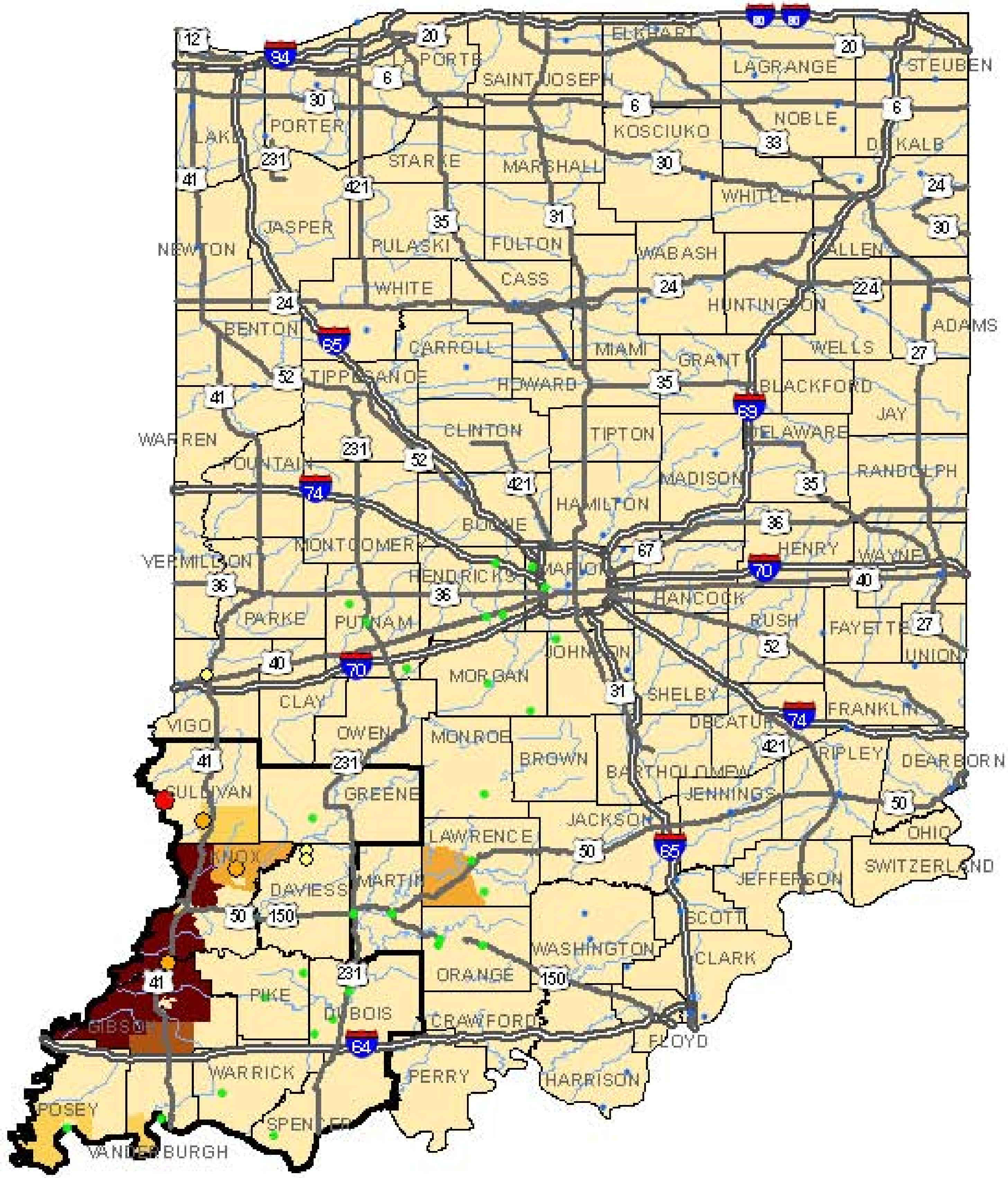
Potable Water Facilities Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	2	0	0
Dubois	3	0	0
Gibson	1	1	0
Greene	1	0	0
Knox	1	1	0
Pike	2	0	0
Posey	1	0	0
Spencer	1	0	0
Sullivan	2	2	0
Vanderburgh	1	0	0
Warrick	1	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Potable Water Pipeline Damage

No. of Leaks

- 0 - 2
- 2 - 10
- 10 - 25
- 25 - 75
- 75 - 160

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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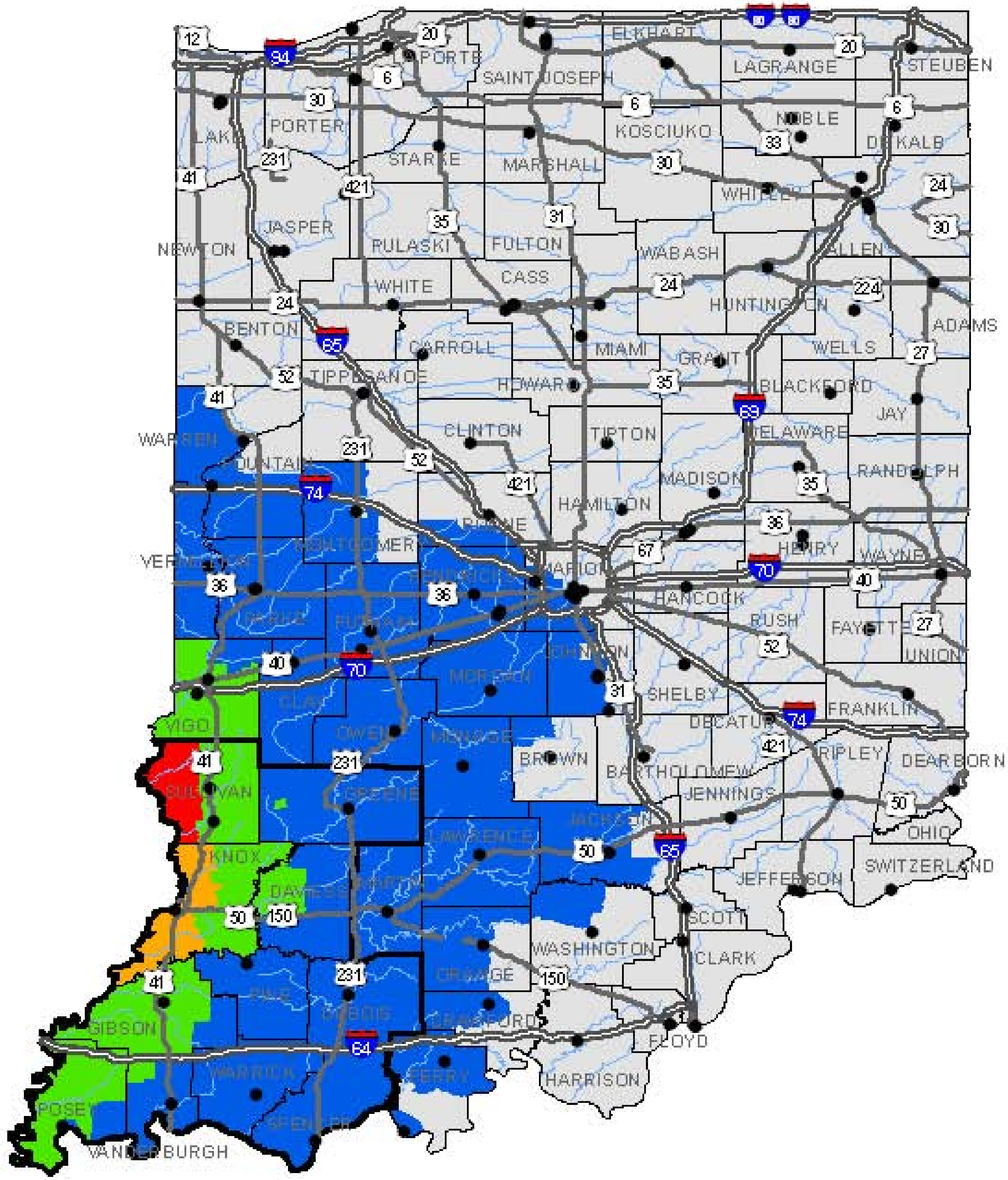
Prisons - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Facilities
Daviess	1
Dubois	0
Gibson	1
Greene	1
Knox	1
Pike	1
Posey	1
Spencer	1
Sullivan	2
Vanderburgh	1
Warrick	1

Legend

- Prisons

MMI

- <VI
- VI
- VII
- VIII
- IX

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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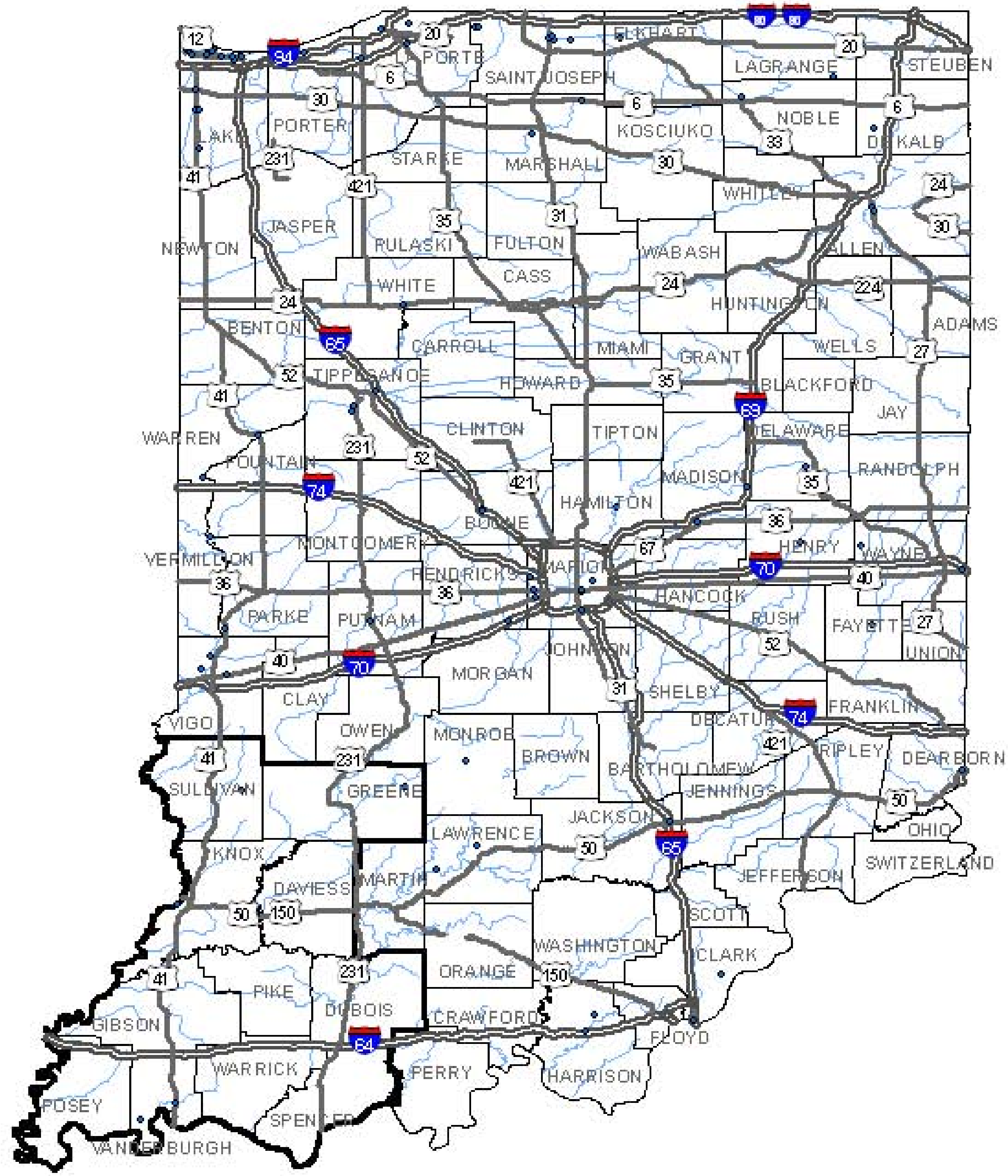
Railway Bridge Functionality: Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Greene	1	1
Knox	2	2
Sullivan	1	1
Vanderburgh	2	2
Daviess	0	0
Dubois	0	0
Gibson	0	0
Pike	0	0
Posey	0	0
Spencer	0	0
Warrick	0	0

Legend

Railway Bridge Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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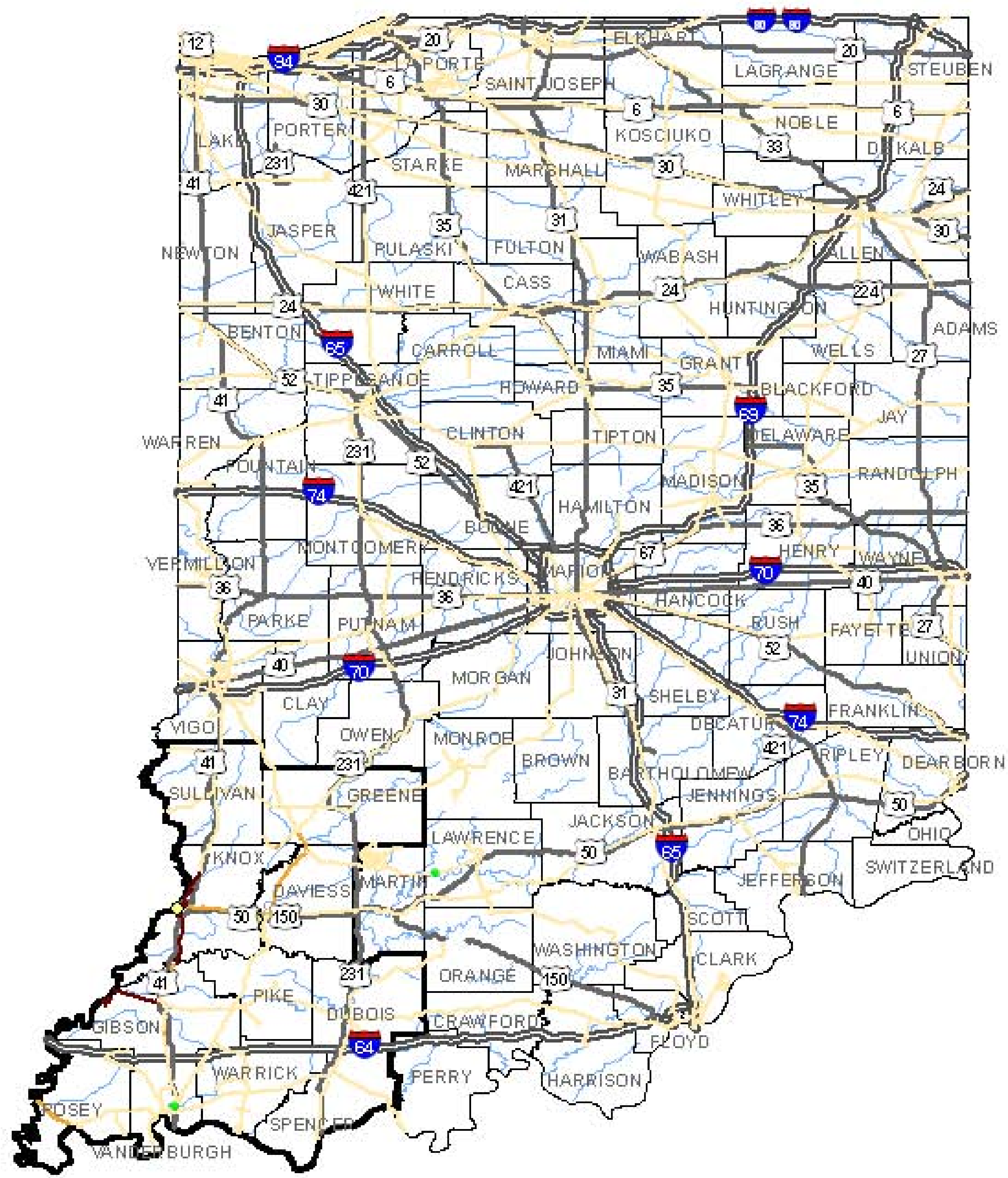
Railway Bridge & Segment Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana
Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Greene	1	0	0
Knox	2	0	0
Sullivan	1	0	0
Vanderburgh	2	0	0
Daviess	0	0	0
Dubois	0	0	0
Gibson	0	0	0
Pike	0	0	0
Posey	0	0	0
Spencer	0	0	0
Warrick	0	0	0

Legend

Railway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Railway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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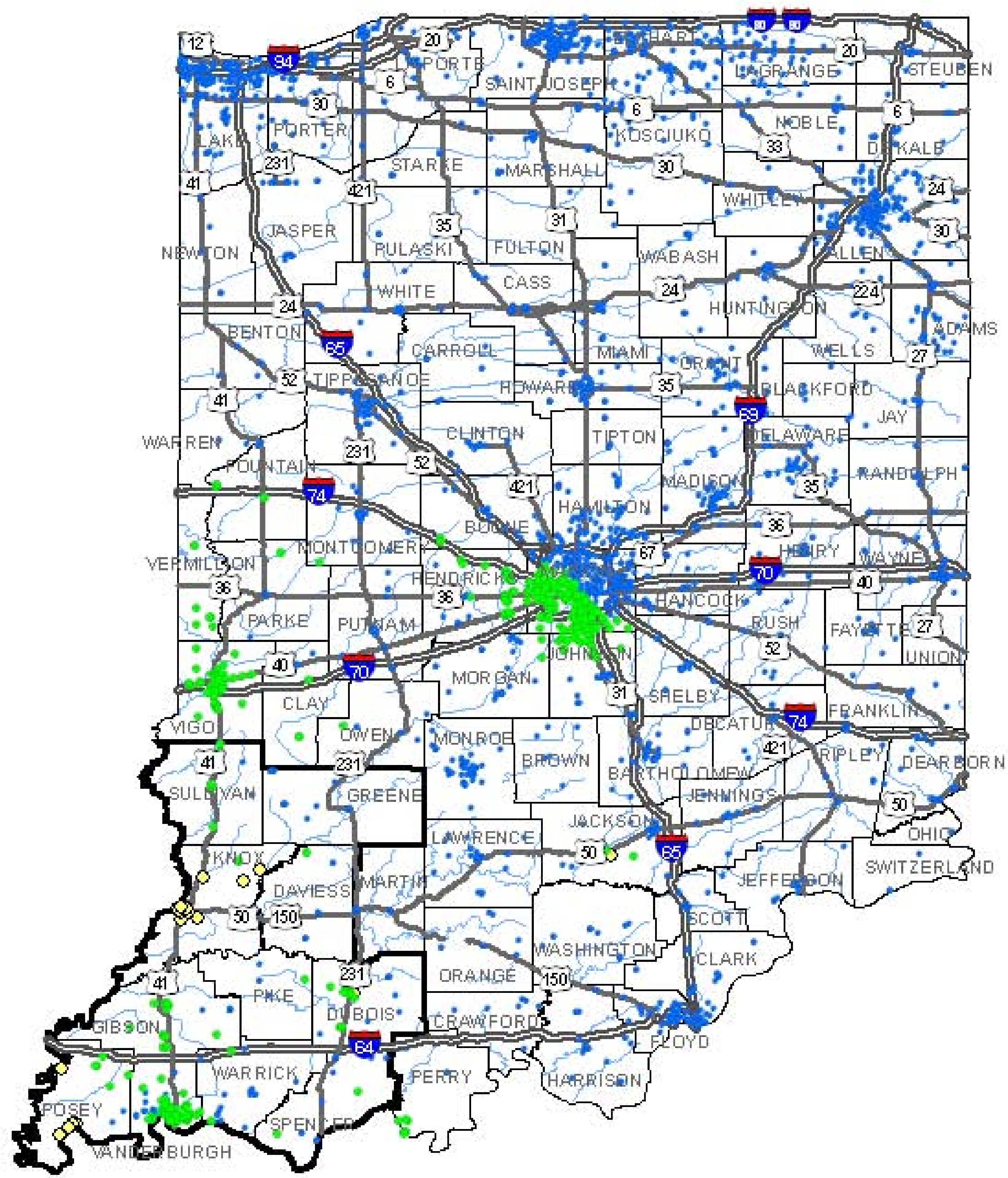
School Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	21	0	0
Dubois	21	0	0
Gibson	20	0	0
Greene	14	0	0
Knox	18	0	0
Pike	5	0	0
Posey	14	0	0
Spencer	13	0	0
Sullivan	10	0	0
Vanderburgh	66	0	0
Warrick	21	0	0

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

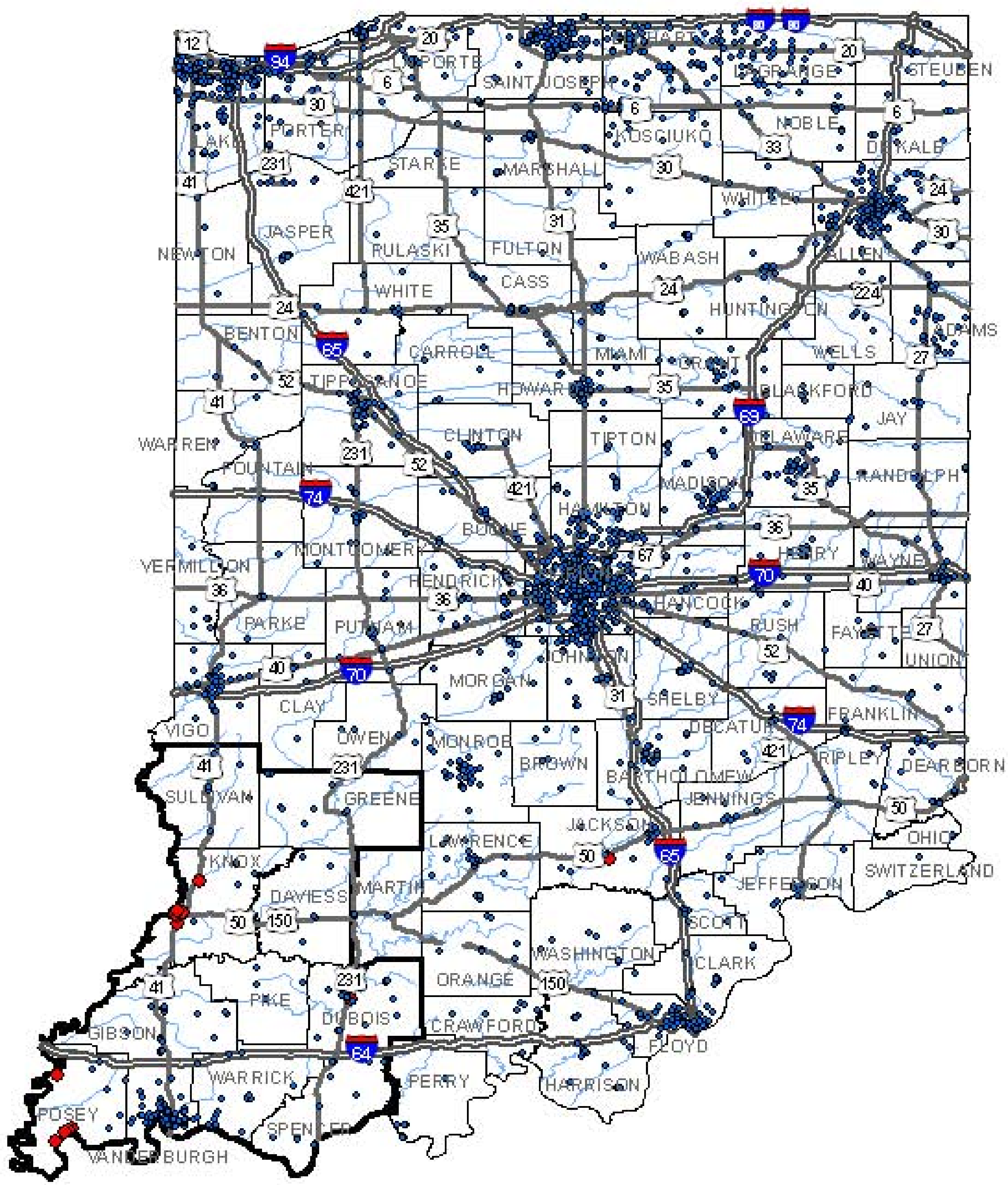
Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

School Functionality at Day 1 - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	No. of Functional Facilities	Total No. of Facilities
Daviess	21	21
Dubois	20	21
Gibson	20	20
Greene	14	14
Knox	7	18
Pike	5	5
Posey	7	14
Spencer	13	13
Sullivan	10	10
Vanderburgh	66	66
Warrick	21	21

Legend

School Functionality Day 1

- Not Functional
- Functional
- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

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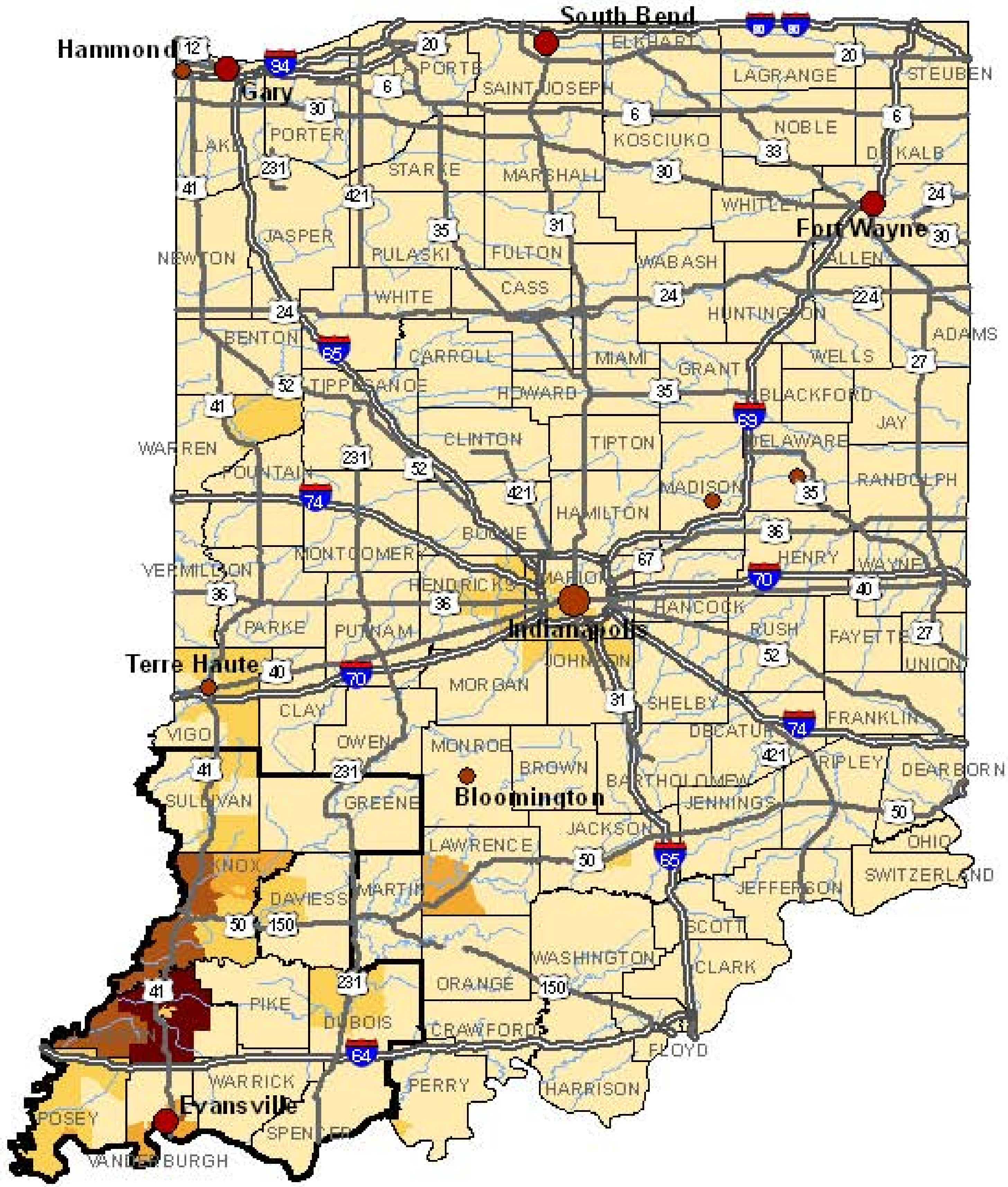
Total Debris - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Brick/ Wood (Tons)	Concrete/ Steel (Tons)	Total Debris (Tons)
Daviess	6,000	2,786	8,786
Dubois	7,561	2,006	9,567
Gibson	77,771	75,347	153,118
Greene	278	18	296
Knox	119,543	139,149	258,692
Pike	686	112	798
Posey	21,084	18,245	39,329
Spencer	184	12	196
Sullivan	5,096	2,069	7,165
Vanderburgh	364,059	644,762	1,008,821
Warrick	389	22	411

Legend

Total Debris

Tons

- 5 - 1,000
- 1,000 - 5,000
- 5,000 - 25,000
- 25,000 - 50,000
- 50,000 - 495,000

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

Interstates

US Routes

Critical Counties

Rivers

0 10 20 40 60

Miles

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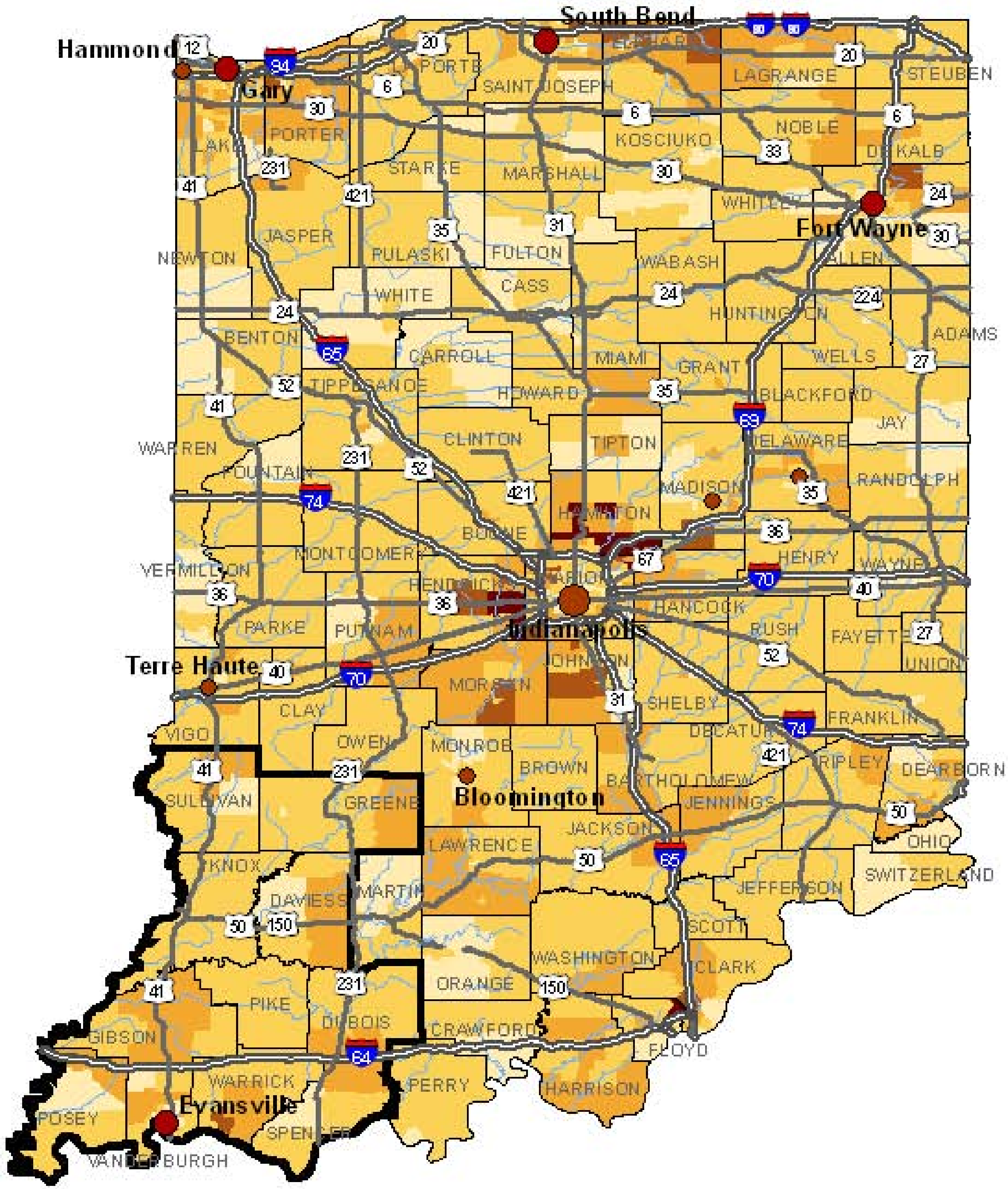
Total Population (2000) - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Population
Daviess	44,373
Dubois	62,739
Gibson	50,515
Greene	48,832
Knox	69,133
Pike	28,529
Posey	27,061
Spencer	31,088
Sullivan	33,573
Vanderburgh	171,922
Warrick	55,182

Legend

Total Population Year 2000 (HAZUS)

- 0 - 3,000
- 3,001 - 6,000
- 6,001 - 90,00
- 9,001 - 12,000
- 12,001 - 17,734

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 753,000

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60
Miles

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Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
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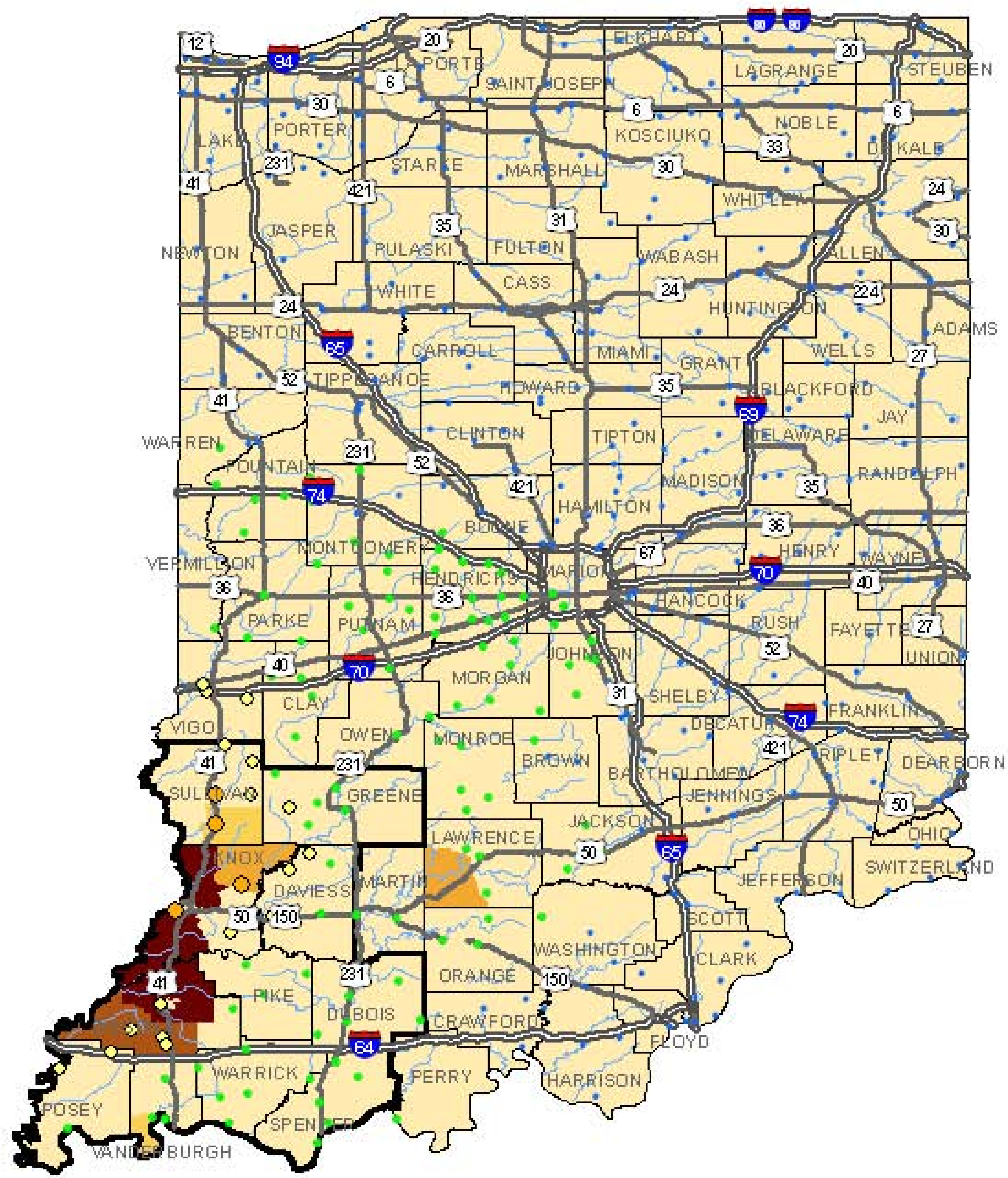
Theresa Jefferson, Principal Investigator

Waste Water Facilities Damage - Wabash Valley Seismic Zone: M7.1 Event

March 2008



State of Indiana Critical Counties (11)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Daviess	5	0	0
Dubois	6	0	0
Gibson	5	0	0
Greene	6	0	0
Knox	3	2	0
Pike	3	0	0
Posey	3	0	0
Spencer	7	0	0
Sullivan	6	2	0
Vanderburgh	3	0	0
Warrick	5	0	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Waste Water Pipeline Damage

No. of Leaks

- 0 - 2
- 2 - 10
- 10 - 25
- 25 - 75
- 75 - 126

- Interstates
- US Routes
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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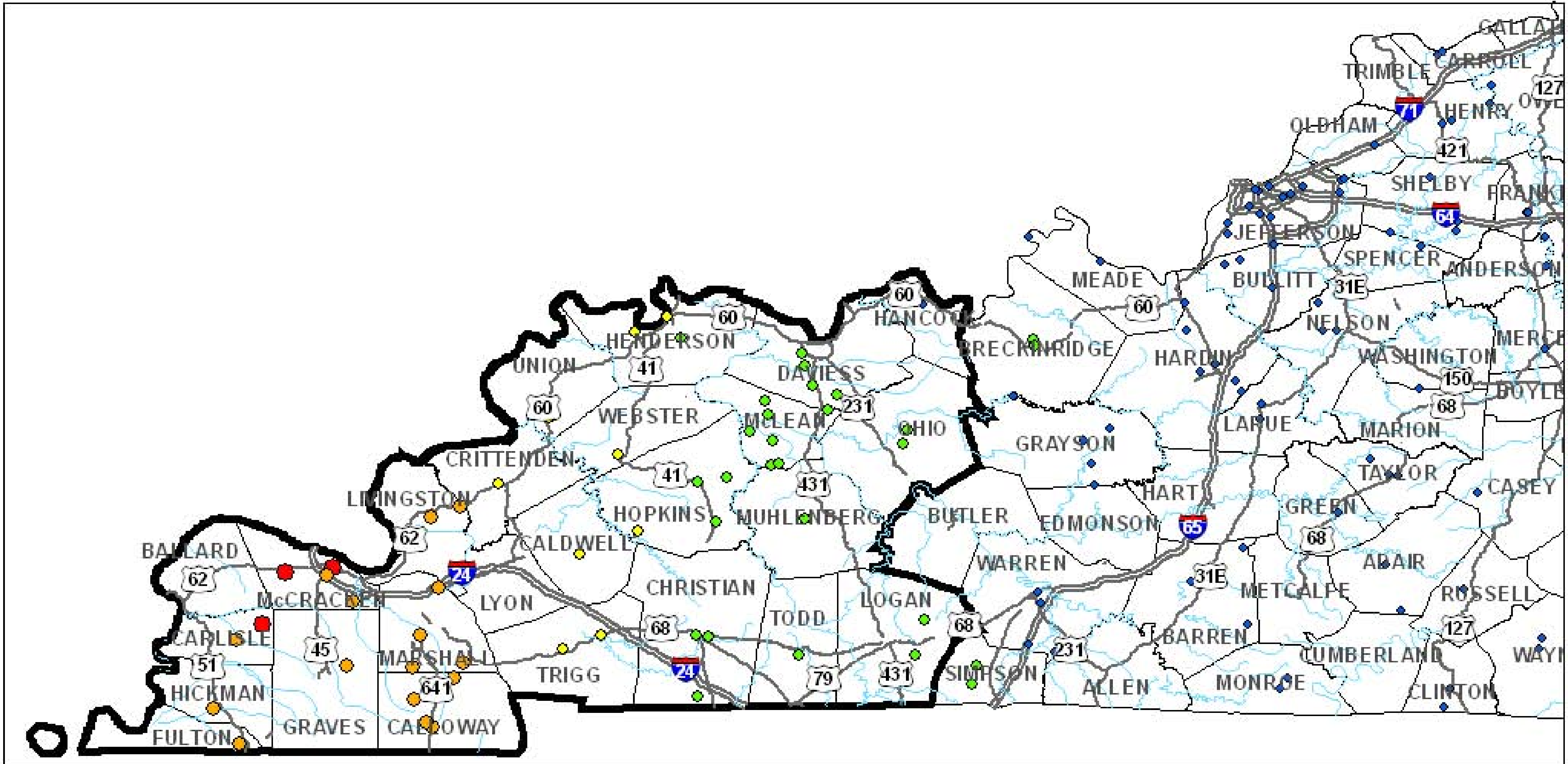
Airport Damage - New Madrid Seismic Zone: M7.7 Event

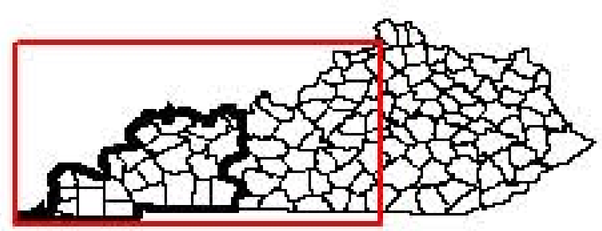
March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	0	0	0
Caldwell	1	0	0
Calloway	4	4	0
Carlisle	2	2	0
Christian	3	0	0
Crittenden	1	0	0
Daviess	4	0	0
Fulton	1	1	0
Graves	1	1	0
Hancock	1	0	0
Henderson	3	0	0
Hickman	1	1	0
Hopkins	4	0	0

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Livingston	2	2	0
Logan	2	0	0
Lyon	0	0	0
Marshall	4	4	0
McCracken	4	4	1
McLean	7	0	0
Muhlenberg	1	0	0
Ohio	2	0	0
Todd	1	0	0
Trigg	2	0	0
Union	1	0	0
Webster	1	0	0



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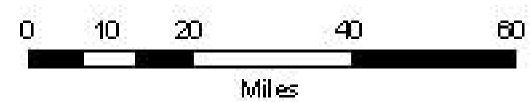
Legend

Airport Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Interstates
US Routes
Rivers



Mid-America Earthquake Center

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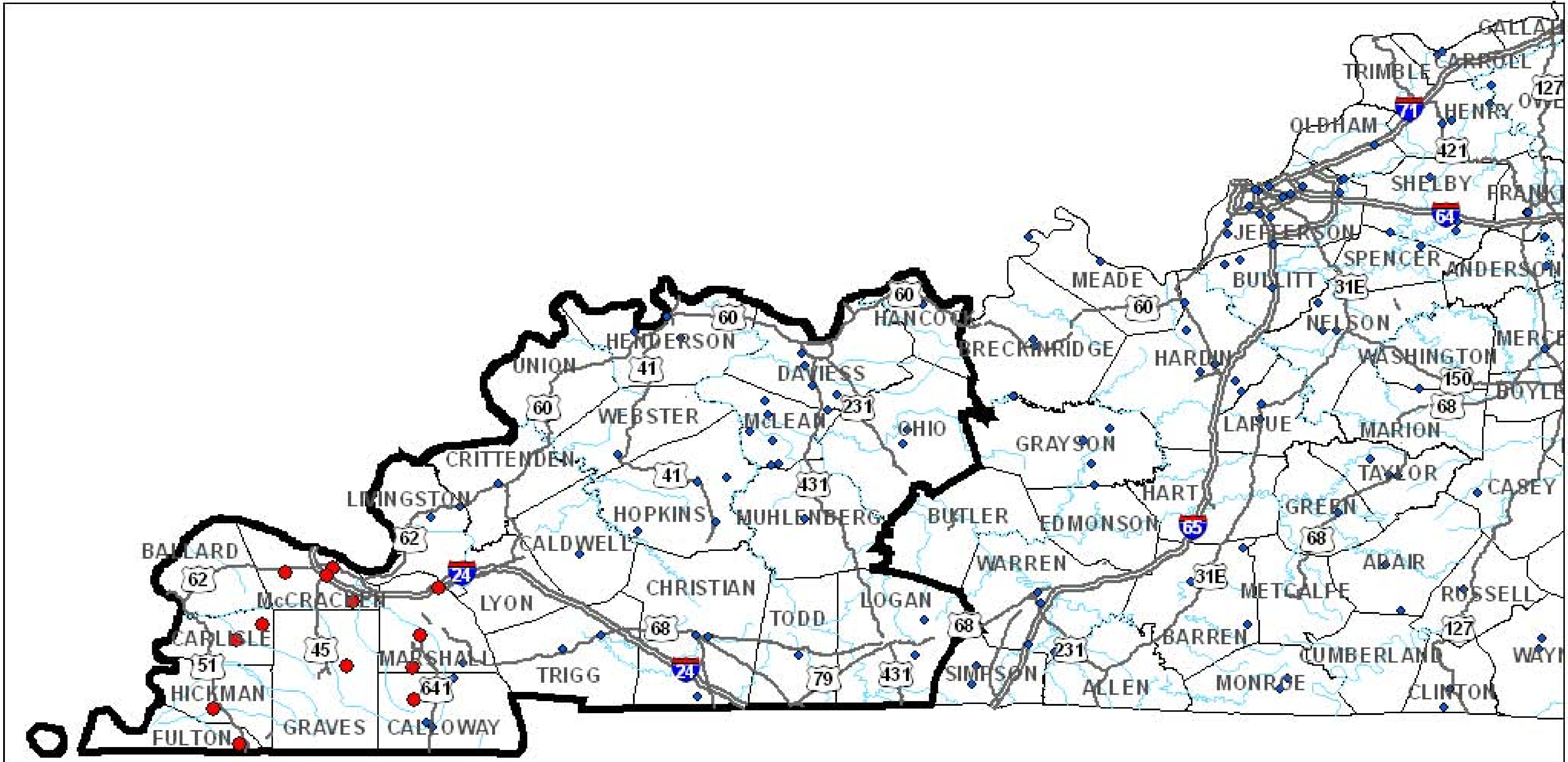
Theresa Jefferson, Principal Investigator

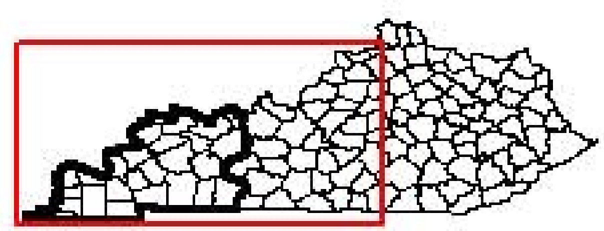
Airport Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities	County	No. of Functional Facilities	Total No. of Facilities
Ballard	0	0	Livingston	2	2
Caldwell	1	1	Logan	2	2
Calloway	3	4	Lyon	0	0
Carlisle	0	2	Marshall	1	4
Christian	3	3	McCracken	0	4
Crittenden	1	1	McLean	7	7
Daviess	4	4	Muhlenberg	1	1
Fulton	0	1	Ohio	2	2
Graves	0	1	Todd	1	1
Hancock	1	1	Trigg	2	2
Henderson	3	3	Union	1	1
Hickman	0	1	Webster	1	1
Hopkins	4	4			



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Legend

Airport Functionality

Day 1

- Not Functional
- Functional

US Routes

Interstates

Critical Counties

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

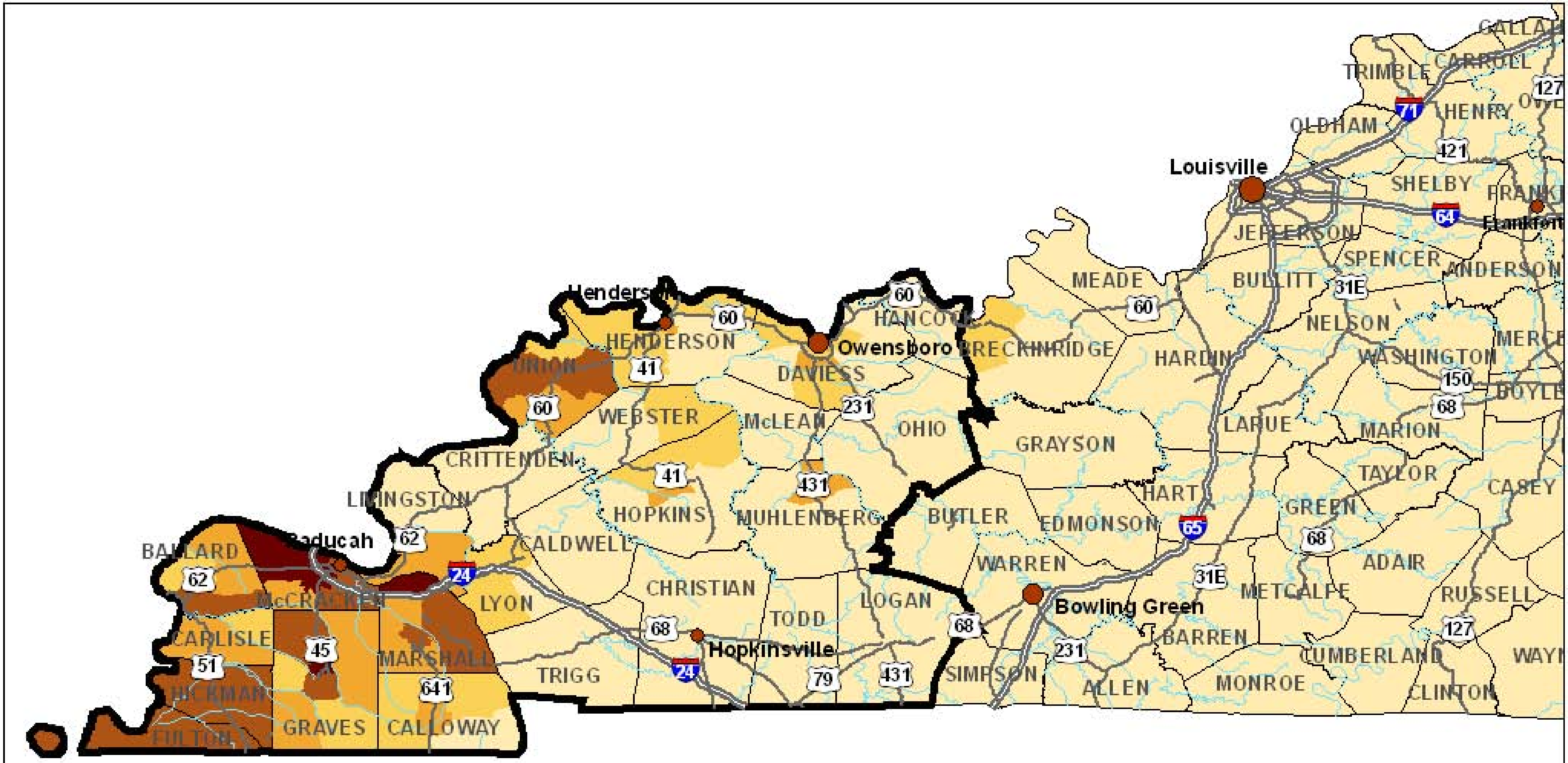
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

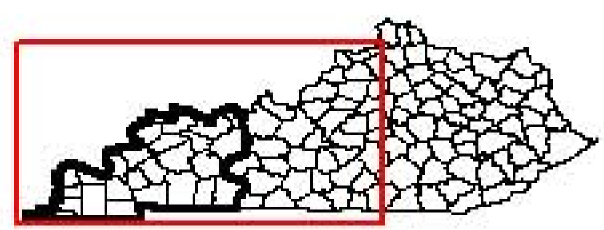
Worst Case Casualties (2PM) - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	No. of Casualties
Ballard	302	20	322
Caldwell	4	0	4
Calloway	346	19	365
Carlisle	190	12	202
Christian	14	0	14
Crittenden	2	0	2
Daviess	687	43	730
Fulton	409	28	437
Graves	1,053	67	1,120
Hancock	0	0	0
Henderson	329	19	348
Hickman	165	11	176
Hopkins	124	6	130
Livingston	68	3	71
Logan	0	0	0
Lyon	18	1	19
McCracken	4,116	283	4,399
McLean	16	1	17
Marshall	895	59	954
Muhlenberg	76	4	80
Ohio	0	0	0
Todd	0	0	0
Trigg	2	0	2
Union	240	15	255
Webster	33	2	35



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Worst Case Casualties (2PM)

- 0 - 25
- 26 - 100
- 101 - 250
- 251 - 500
- 501 - 1,725

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center

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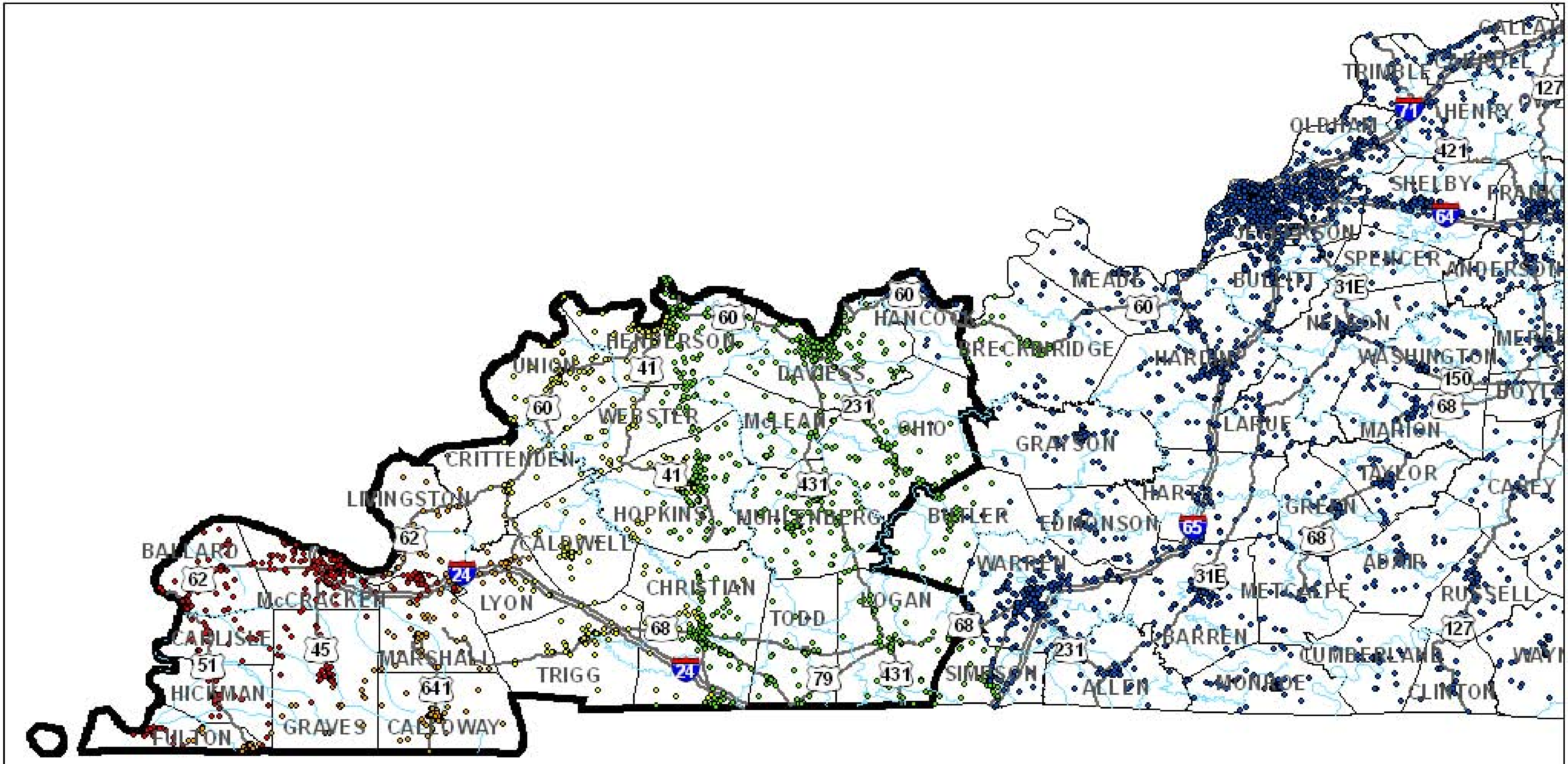
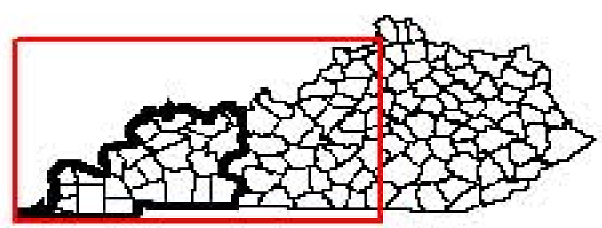
Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	92	92	53	Livingston	82	82	0
Caldwell	70	0	0	Logan	125	0	0
Calloway	111	111	0	Lyon	62	54	0
Carlisle	42	42	1	Marshall	146	146	0
Christian	265	0	0	McCracken	251	251	79
Crittenden	61	2	0	McLean	53	0	0
Daviess	338	0	0	Muhlenberg	177	0	0
Fulton	63	63	0	Ohio	127	0	0
Graves	158	158	0	Todd	63	0	0
Hancock	85	0	0	Trigg	71	0	0
Henderson	320	0	0	Union	113	0	0
Hickman	43	43	0	Webster	89	0	0
Hopkins	255	0	0				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Communication Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Interstates
US Routes
Rivers

0 10 20 40 60
Miles

Mid-America Earthquake Center

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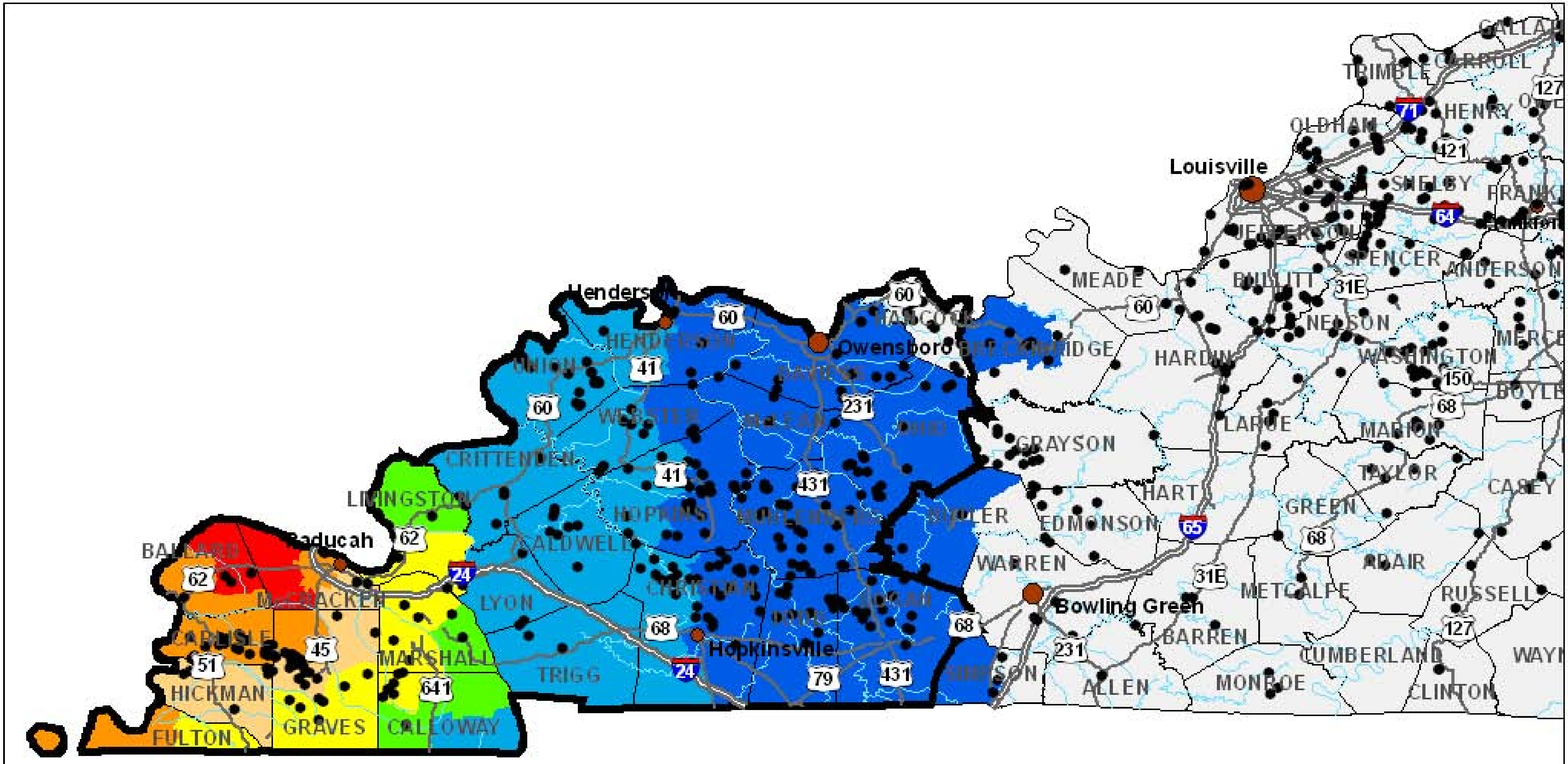
Theresa Jefferson, Principal Investigator

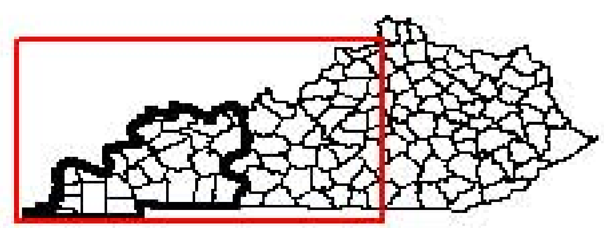
Dams - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Facilities	County	No. of Facilities	County	No. of Facilities
Ballard	5	Hancock	14	McLean	3
Caldwell	9	Henderson	10	Muhlenberg	31
Calloway	8	Hickman	5	Ohio	22
Carlisle	23	Hopkins	33	Todd	12
Christian	32	Livingston	4	Trigg	3
Crittenden	6	Logan	16	Union	34
Daviess	13	Lyon	3	Webster	10
Fulton	0	Marshall	6		
Graves	28	McCracken	3		



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Legend

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

- Dams

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

US Routes — Rivers — Interstates — Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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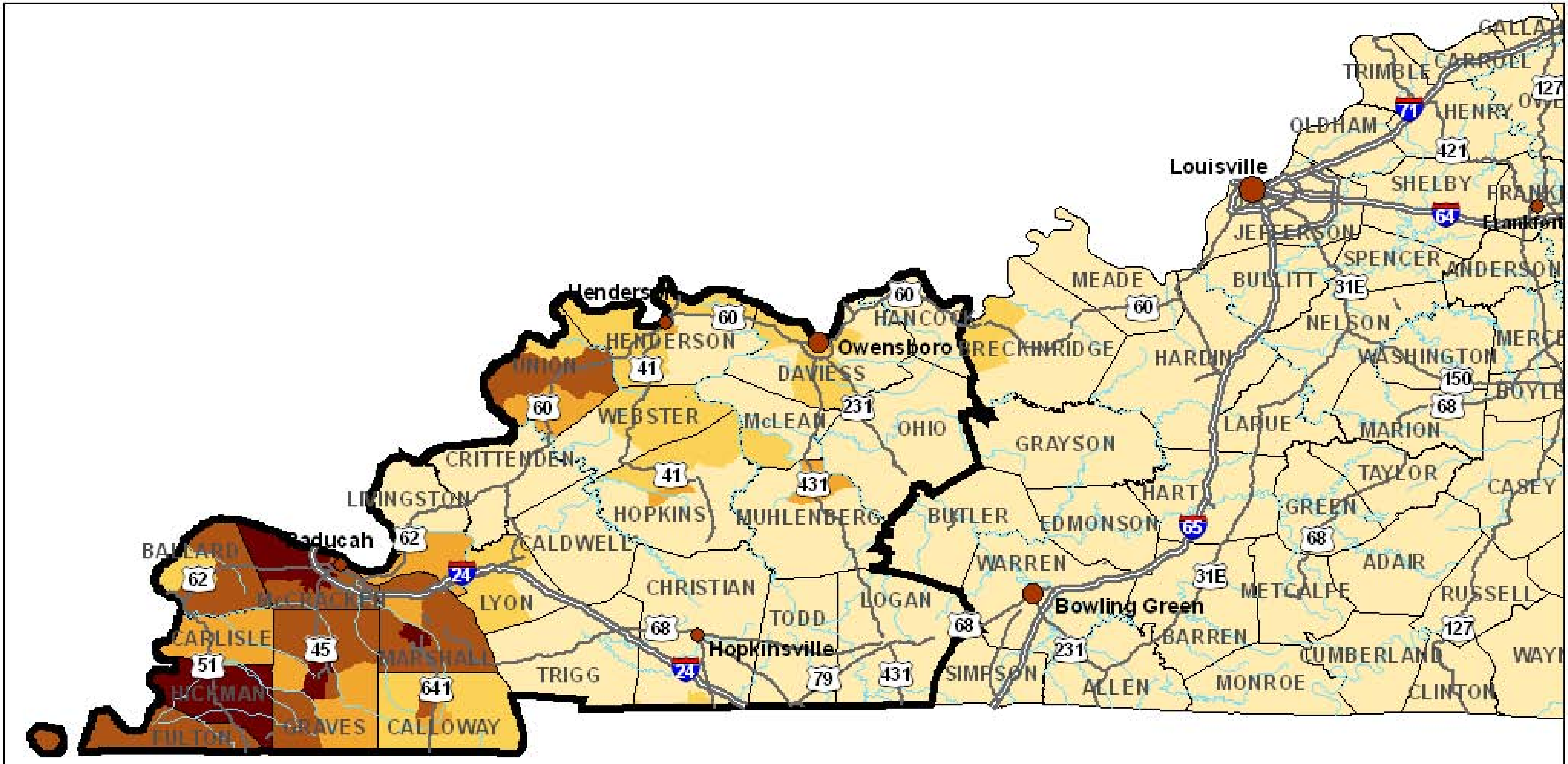
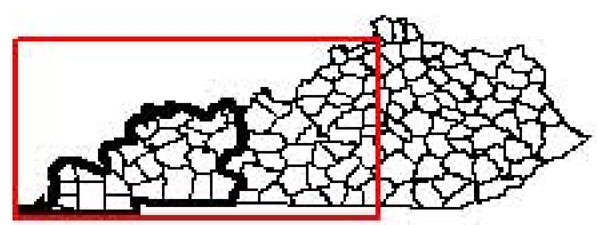
Total Debris - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Brick/Wood (Thousands of Tons)	Concrete/Steel (Thousands of Tons)	Total Debris (Thousands of Tons)
Ballard	87	96	183
Caldwell	3	1	5
Calloway	122	129	251
Carlisle	66	69	135
Christian	16	8	24
Crittenden	2	1	3
Daviess	158	175	333
Fulton	78	91	169
Graves	307	340	647
Hancock	0	0	0
Henderson	87	93	180
Hickman	51	51	102
Hopkins	49	40	90
Livingston	24	21	44
Logan	0	0	0
Lyon	6	5	11
McCracken	756	879	1,636
McLean	7	6	13
Marshall	215	227	442
Muhlenberg	16	19	35
Ohio	0	0	0
Todd	0	0	0
Trigg	3	1	5
Union	66	72	137
Webster	14	13	27



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Total Debris (Thousands of Tons)
- 0 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 235

Major Cities
- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center

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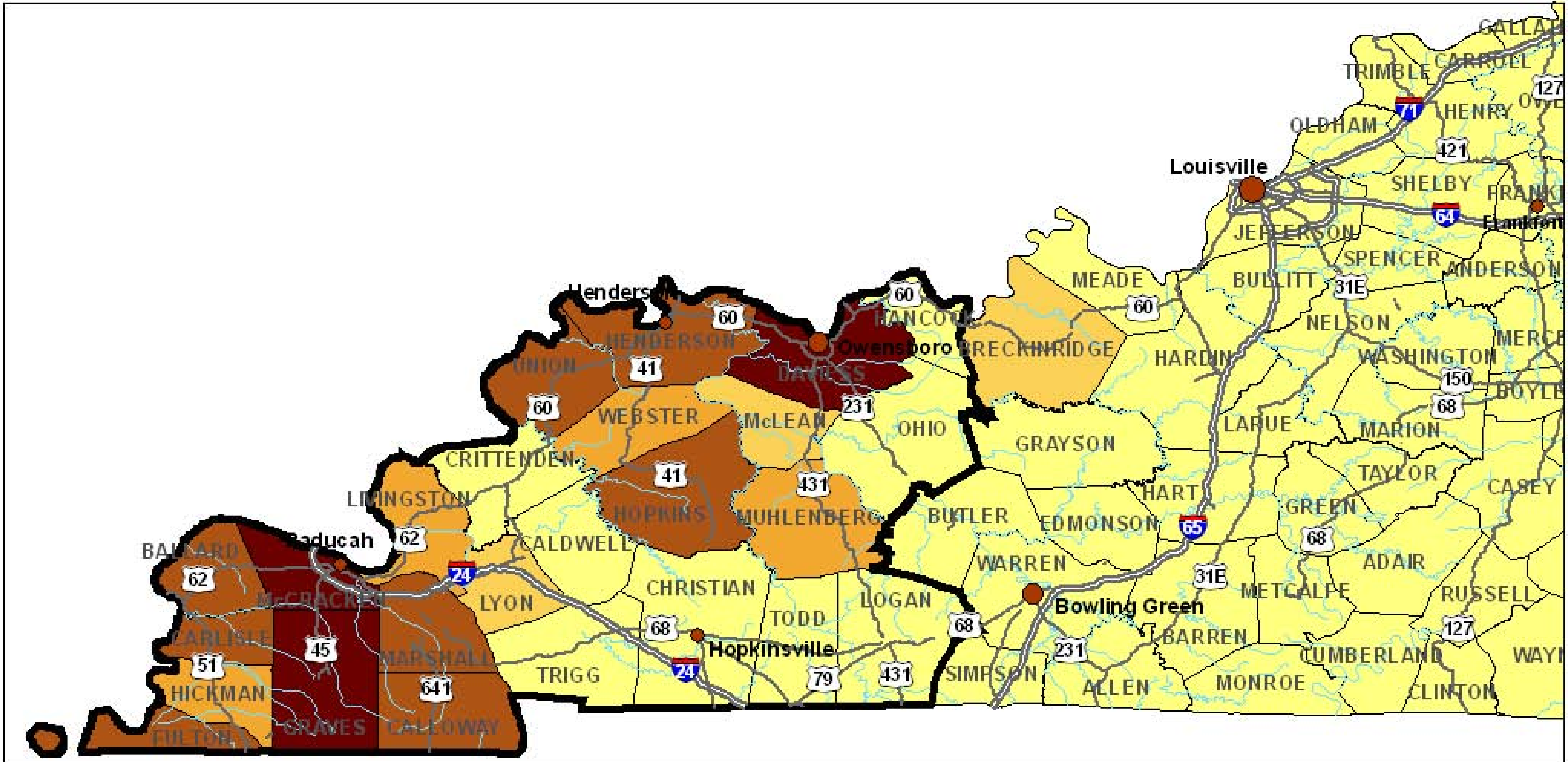
Theresa Jefferson, Principal Investigator

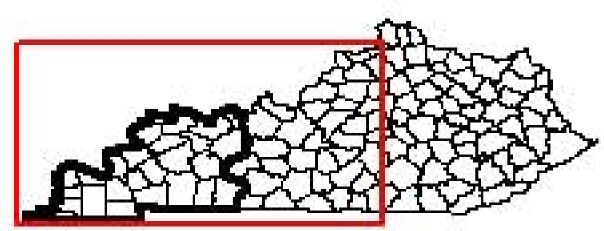
Displaced Population - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Displaced Residences	Estimate of Displaced Population
Ballard	1,275	3,113
Caldwell	8	20
Calloway	1,243	3,064
Carlisle	1,051	2,548
Christian	5	15
Crittenden	0	0
Daviess	3,817	9,697
Fulton	1,156	2,769
Graves	4,307	10,745
Hancock	0	0
Henderson	1,963	4,864
Hickman	740	1,779
Hopkins	993	2,453
Livingston	205	504
Logan	0	0
Lyon	76	212
McCracken	10,321	24,379
McLean	172	428
Marshall	2288	5553
Muhlenberg	379	975
Ohio	0	0
Todd	0	0
Trigg	0	1
Union	1,427	3,907
Webster	293	745



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Displaced Population

- 0 - 50
- 51 - 500
- 501 - 2,000
- 2,001 - 6,000
- 6,001 - 24,400

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

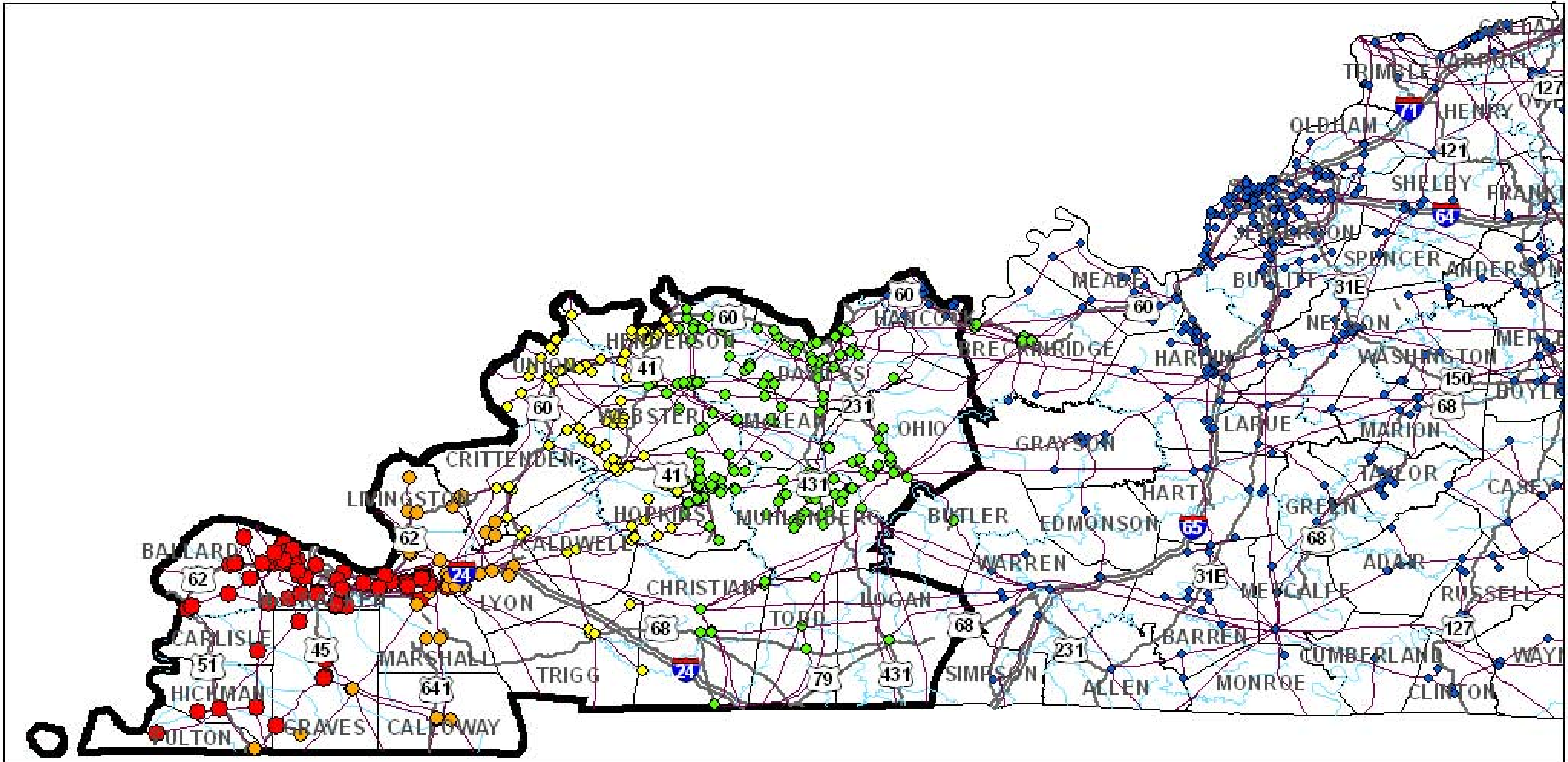
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

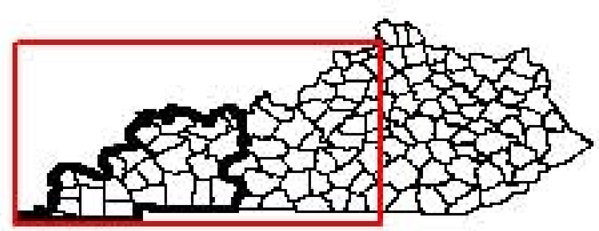
Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	9	9	6
Caldwell	4	0	0
Calloway	4	4	0
Carlisle	1	1	0
Christian	8	0	0
Crittenden	11	5	0
Daviess	40	0	0
Fulton	2	2	0
Graves	9	9	0
Hancock	25	0	0
Henderson	51	0	0
Hickman	3	3	0
Hopkins	57	0	0
Livingston	21	21	0
Logan	2	0	0
Lyon	14	14	0
Marshall	17	17	0
McCracken	47	47	34
McLean	9	0	0
Muhlenberg	46	0	0
Ohio	22	0	0
Todd	4	0	0
Trigg	4	0	0
Union	18	0	0
Webster	35	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Electric Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers
- Major Electric Lines

0 10 20 40 60

Miles

Mid-America Earthquake Center

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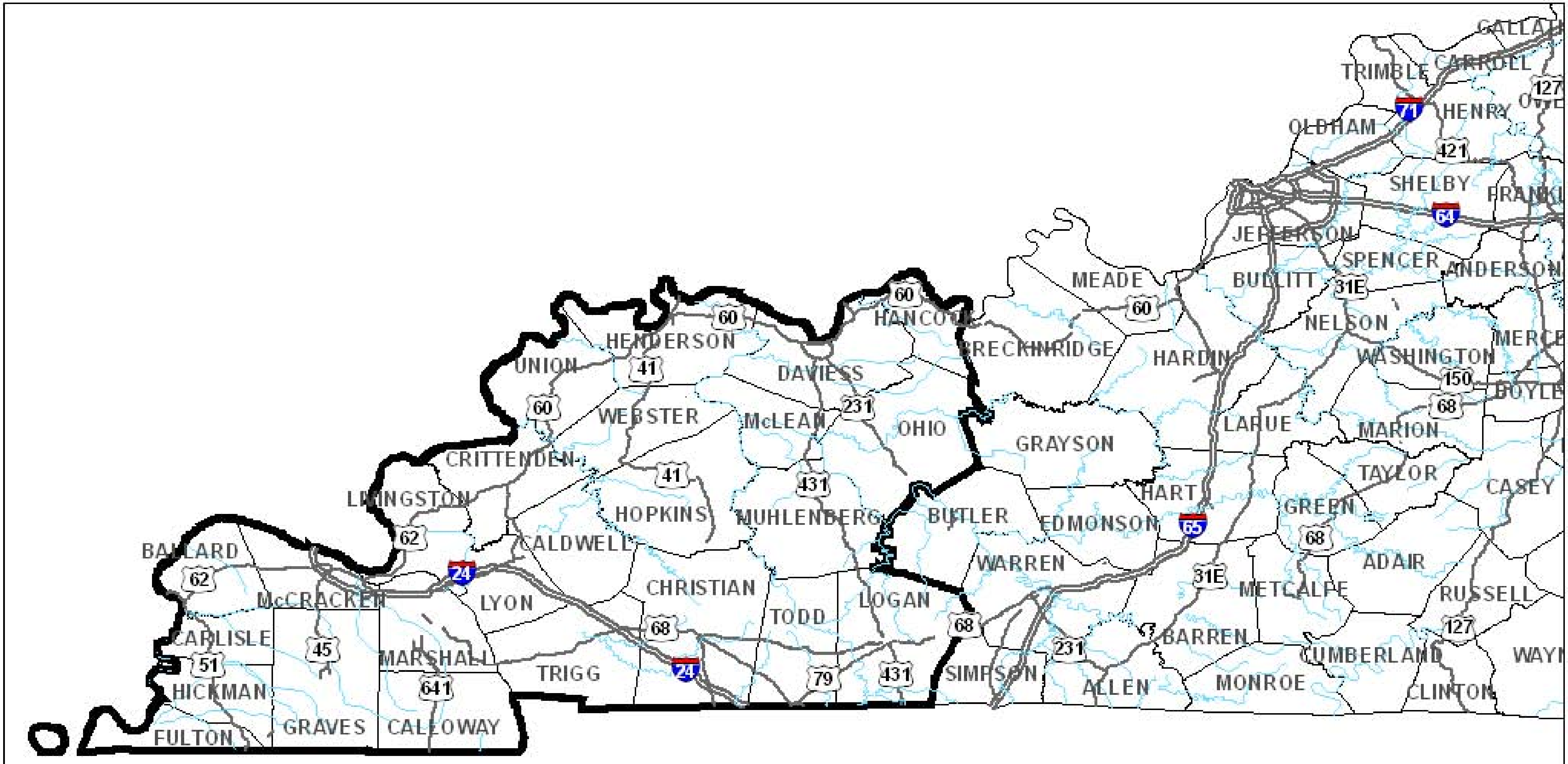
Theresa Jefferson, Principal Investigator

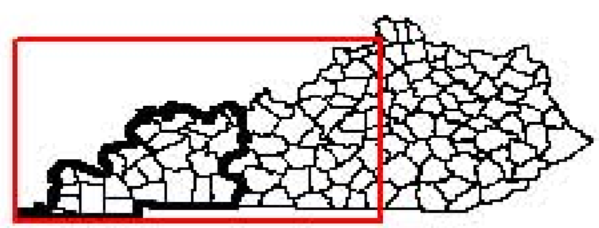
Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	0	0	0
Caldwell	0	0	0
Calloway	0	0	0
Carlisle	0	0	0
Christian	0	0	0
Crittenden	0	0	0
Daviess	0	0	0
Fulton	0	0	0
Graves	0	0	0
Hancock	0	0	0
Henderson	0	0	0
Hickman	0	0	0
Hopkins	0	0	0
Livingston	0	0	0
Logan	0	0	0
Lyon	0	0	0
McCracken	0	0	0
McLean	0	0	0
Marshall	0	0	0
Muhlenberg	0	0	0
Ohio	0	0	0
Todd	0	0	0
Trigg	0	0	0
Union	0	0	0
Webster	0	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Emergency Operation Centers

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers

0 10 20 40 60

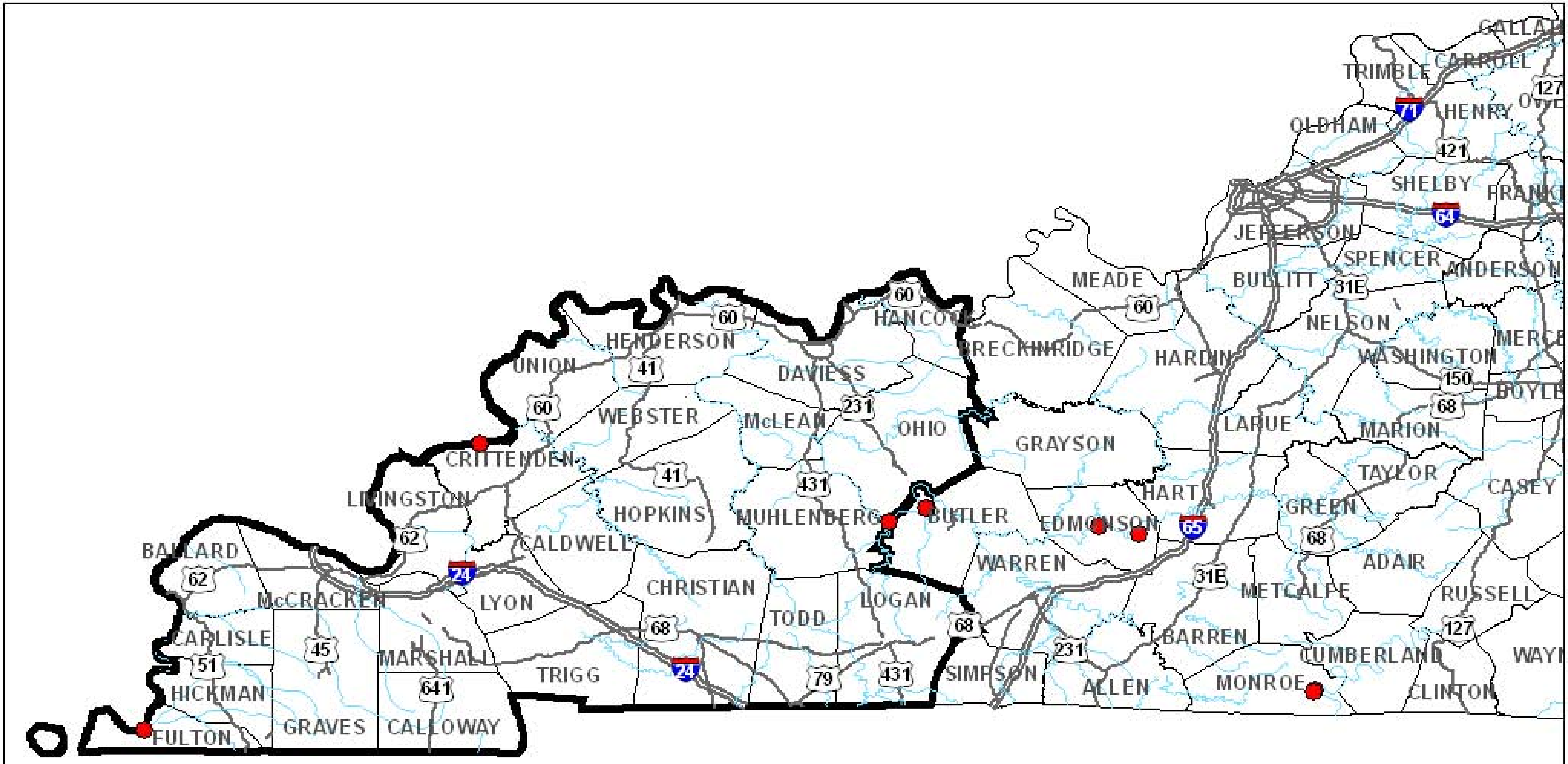
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

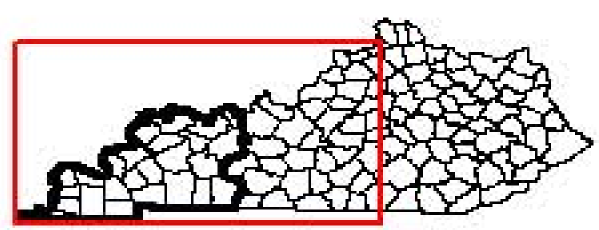
Ferry Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Crittenden	1	1	1
Fulton	1	1	1
Ohio	1	1	1
Ballard	0	0	0
Caldwell	0	0	0
Calloway	0	0	0
Carlisle	0	0	0
Christian	0	0	0
Daviess	0	0	0
Graves	0	0	0
Hancock	0	0	0
Henderson	0	0	0
Hickman	0	0	0
Hopkins	0	0	0
Livingston	0	0	0
Logan	0	0	0
Lyon	0	0	0
McCracken	0	0	0
McLean	0	0	0
Marshall	0	0	0
Muhlenberg	0	0	0
Todd	0	0	0
Trigg	0	0	0
Union	0	0	0
Webster	0	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers

0 10 20 40 60

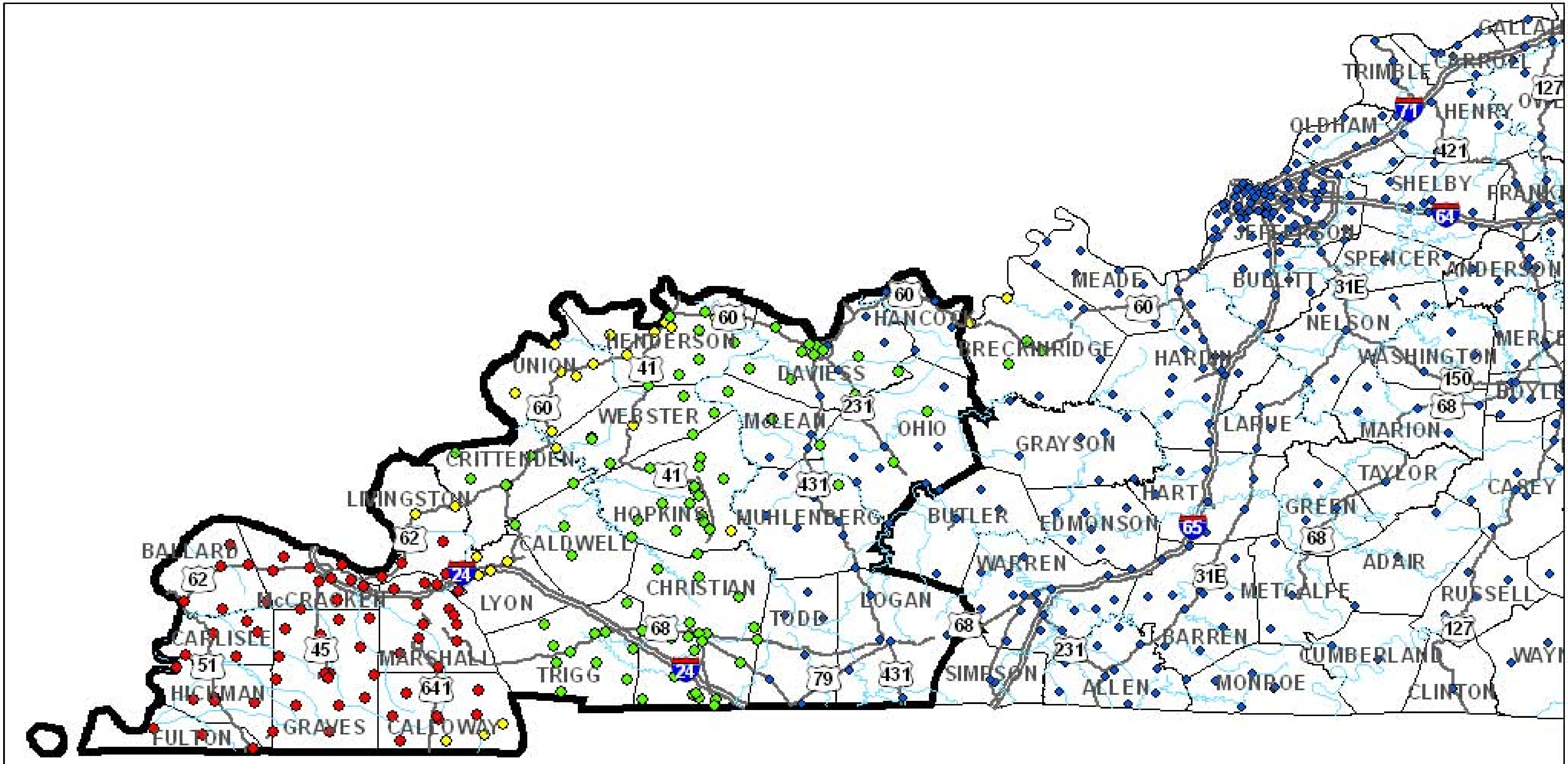
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

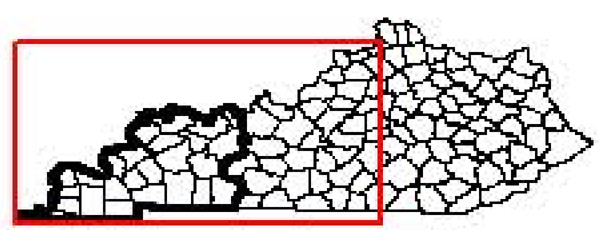
Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	10	10	8
Caldwell	3	0	0
Calloway	11	8	0
Carlisle	6	6	6
Christian	23	0	0
Crittenden	7	0	0
Daviess	17	0	0
Fulton	3	3	3
Graves	18	18	18
Hancock	4	0	0
Henderson	14	0	0
Hickman	5	5	5
Hopkins	18	0	0
Livingston	8	6	0
Logan	6	0	0
Lyon	4	0	0
McCracken	9	9	9
McLean	8	0	0
Marshall	12	12	12
Muhlenberg	8	0	0
Ohio	9	0	0
Todd	7	0	0
Trigg	11	0	0
Union	8	0	0
Webster	9	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Interstates

US Routes

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

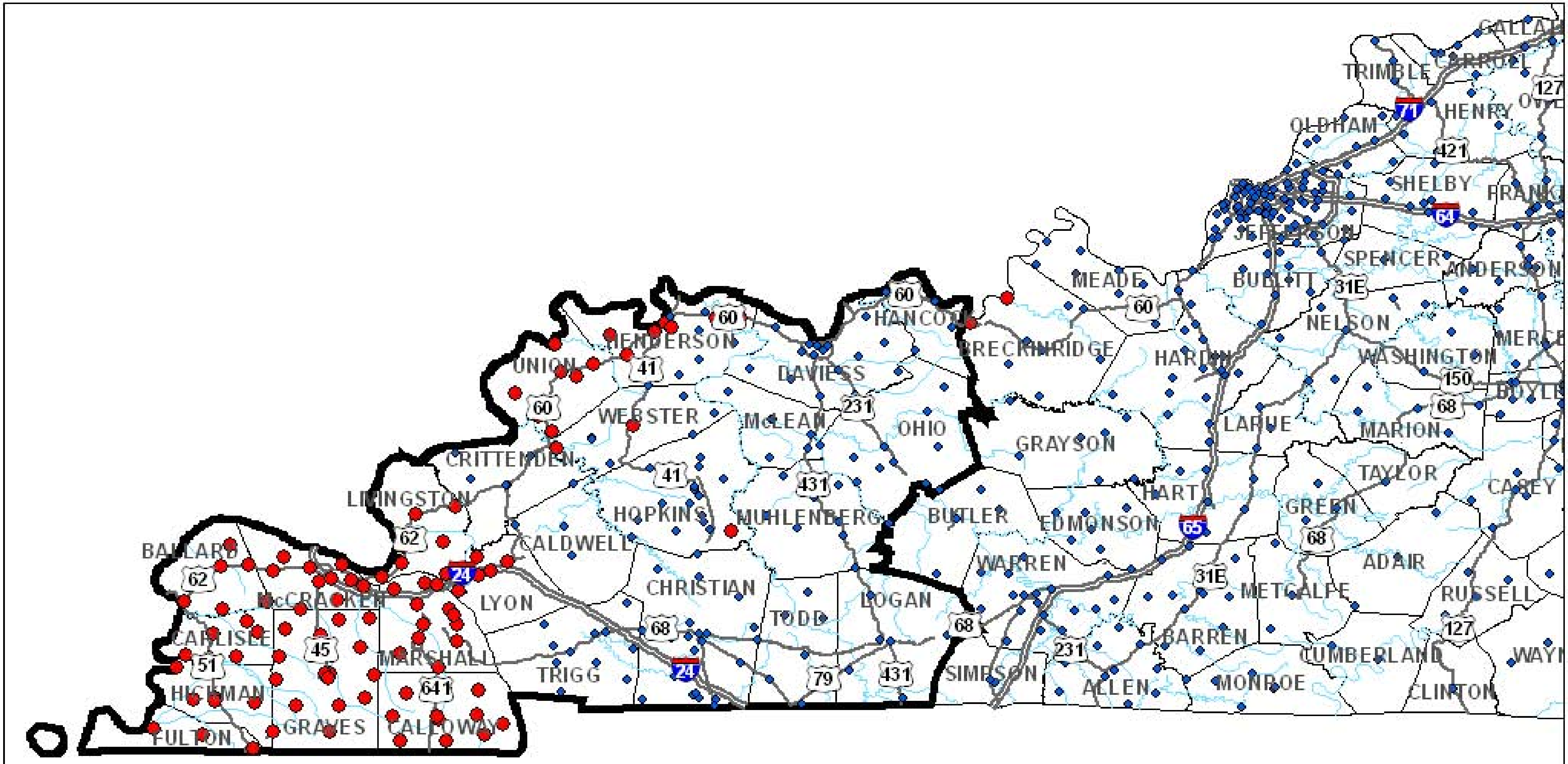
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

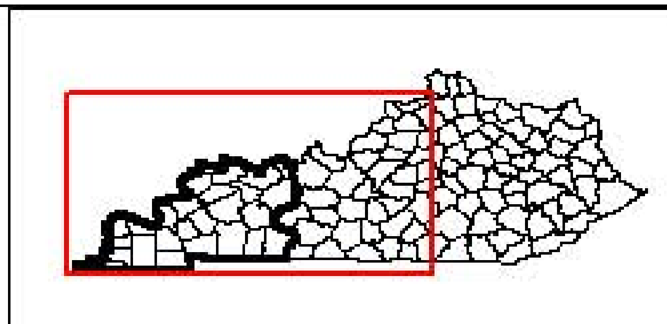
Fire Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Ballard	0	10
Caldwell	3	3
Calloway	0	11
Carlisle	0	6
Christian	23	23
Crittenden	7	7
Daviess	17	17
Fulton	0	3
Graves	0	18
Hancock	4	4
Henderson	6	14
Hickman	0	5
Hopkins	17	18
Livingston	0	8
Logan	6	6
Lyon	0	4
Marshall	0	12
McCracken	0	9
McLean	8	8
Muhlenberg	8	8
Ohio	9	9
Todd	7	7
Trigg	11	11
Union	0	8
Webster	7	9



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Fire Station Functionality

Day 1

- Not Functional
- Functional

US Routes

Interstates

Critical Counties

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

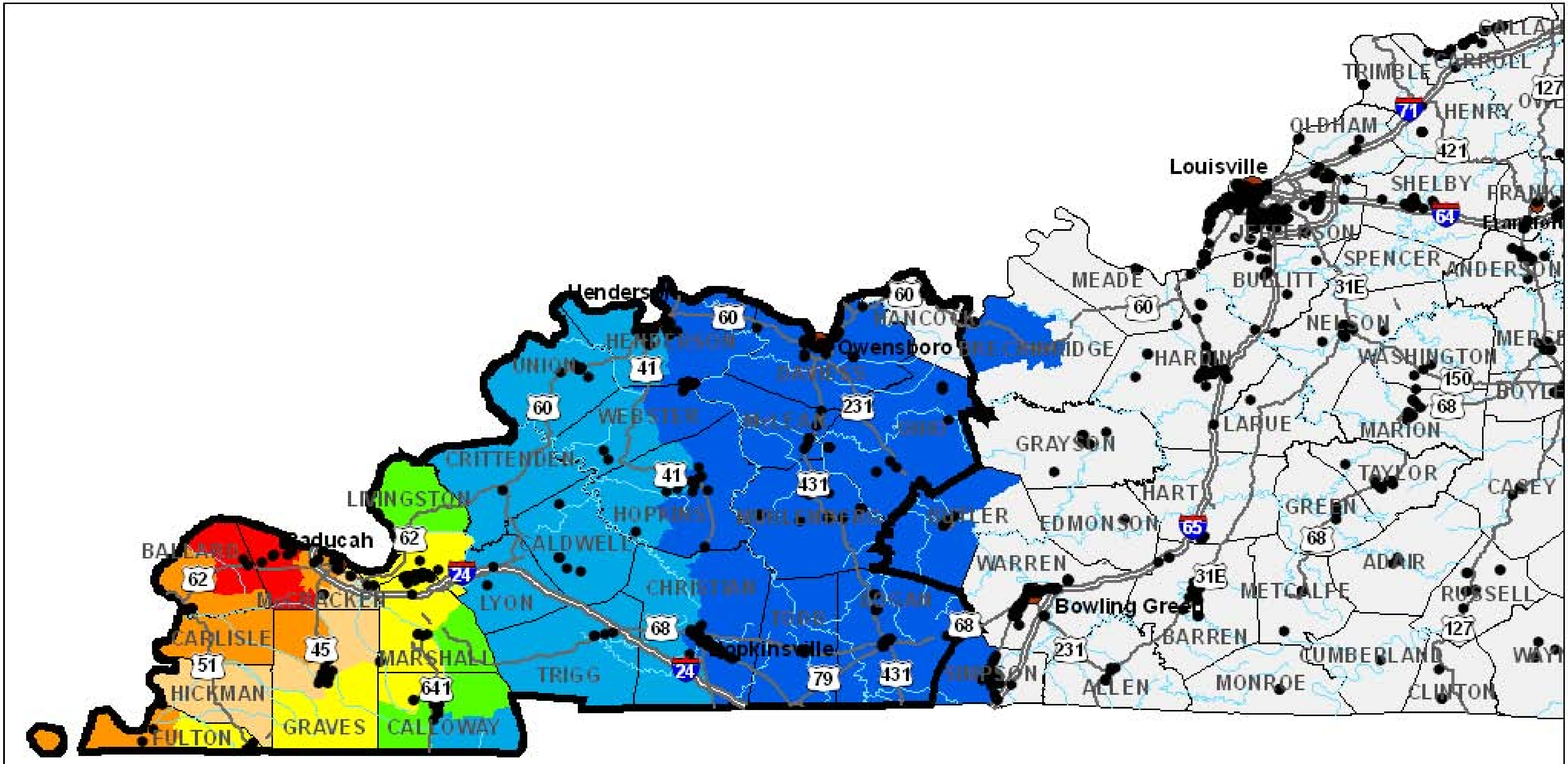
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

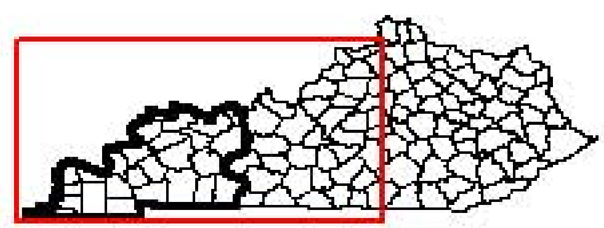
Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Facilities	County	No. of Facilities	County	No. of Facilities
Ballard	28	Hancock	74	McLean	7
Caldwell	7	Henderson	81	Muhlenberg	54
Calloway	21	Hickman	0	Ohio	20
Carlisle	0	Hopkins	21	Todd	5
Christian	53	Livingston	2	Trigg	5
Crittenden	1	Logan	34	Union	13
Daviess	69	Lyon	2	Webster	19
Fulton	9	Marshall	231		
Graves	18	McCracken	47		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

- US Routes
- Hazardous Materials Facilities
- Rivers
- Interstates
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

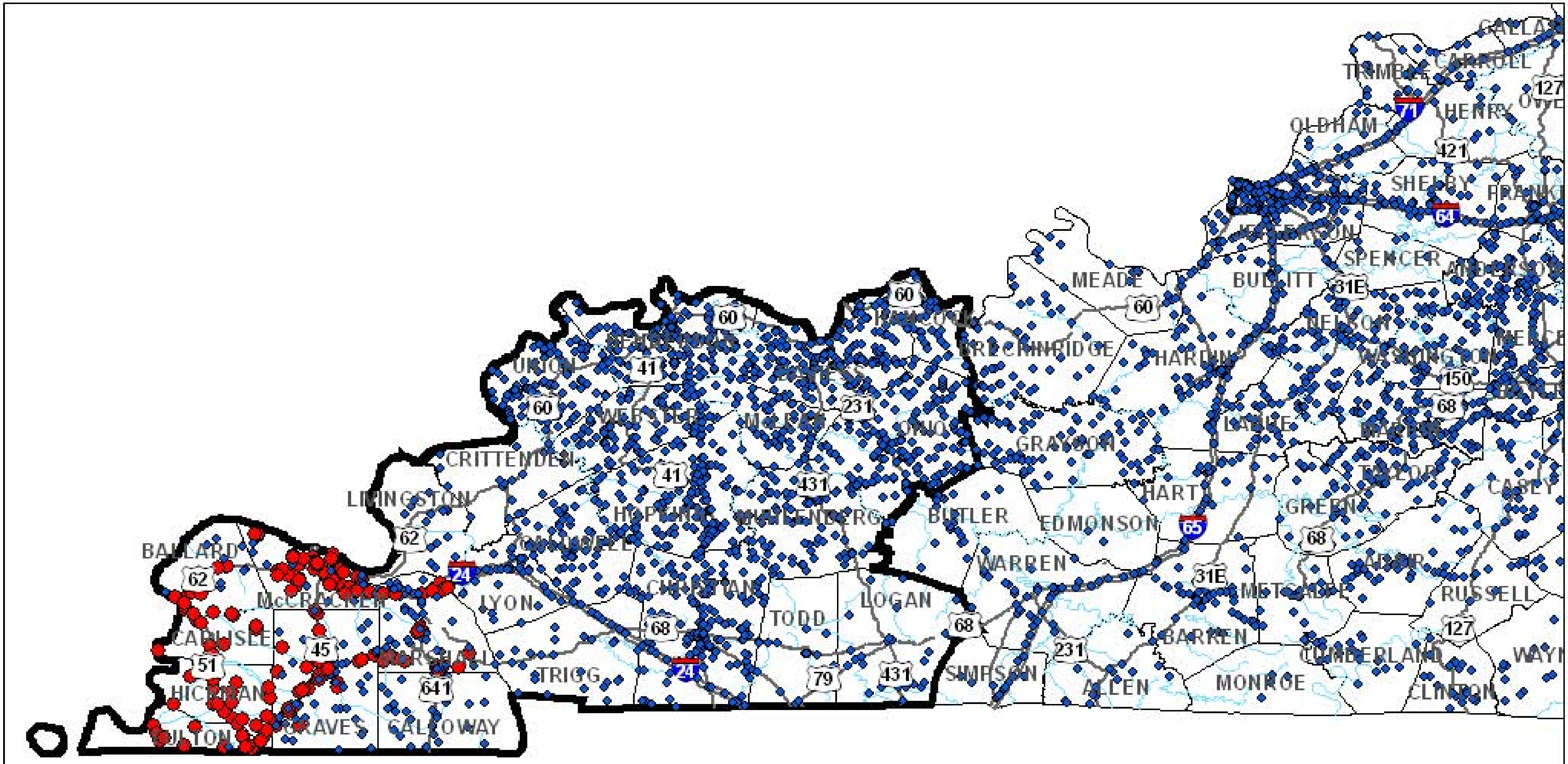
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

Highway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

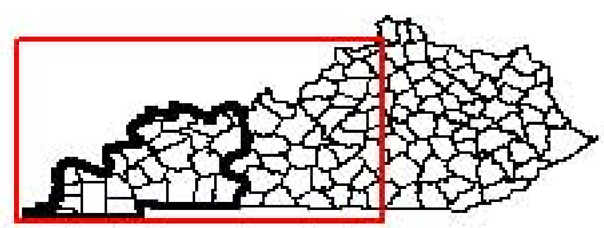
March 2008



State of Kentucky - Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Ballard	12	25
Caldwell	84	84
Calloway	34	36
Carlisle	0	15
Christian	202	202
Crittenden	19	19
Daviess	233	233
Fulton	2	18
Graves	80	122
Hancock	64	64
Henderson	171	171
Hickman	0	22
Hopkins	207	207

County	No. of Functional Facilities	Total No. of Facilities
Livingston	29	30
Logan	33	33
Lyon	49	49
McCracken	18	80
McLean	64	64
Marshall	64	90
Muhlenberg	127	127
Ohio	190	190
Todd	22	22
Trigg	38	38
Union	114	114
Webster	118	118



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Highway Bridge Functionality

Day 1

- Not Functional
- Functional

US Routes
Interstates
Critical Counties
Rivers

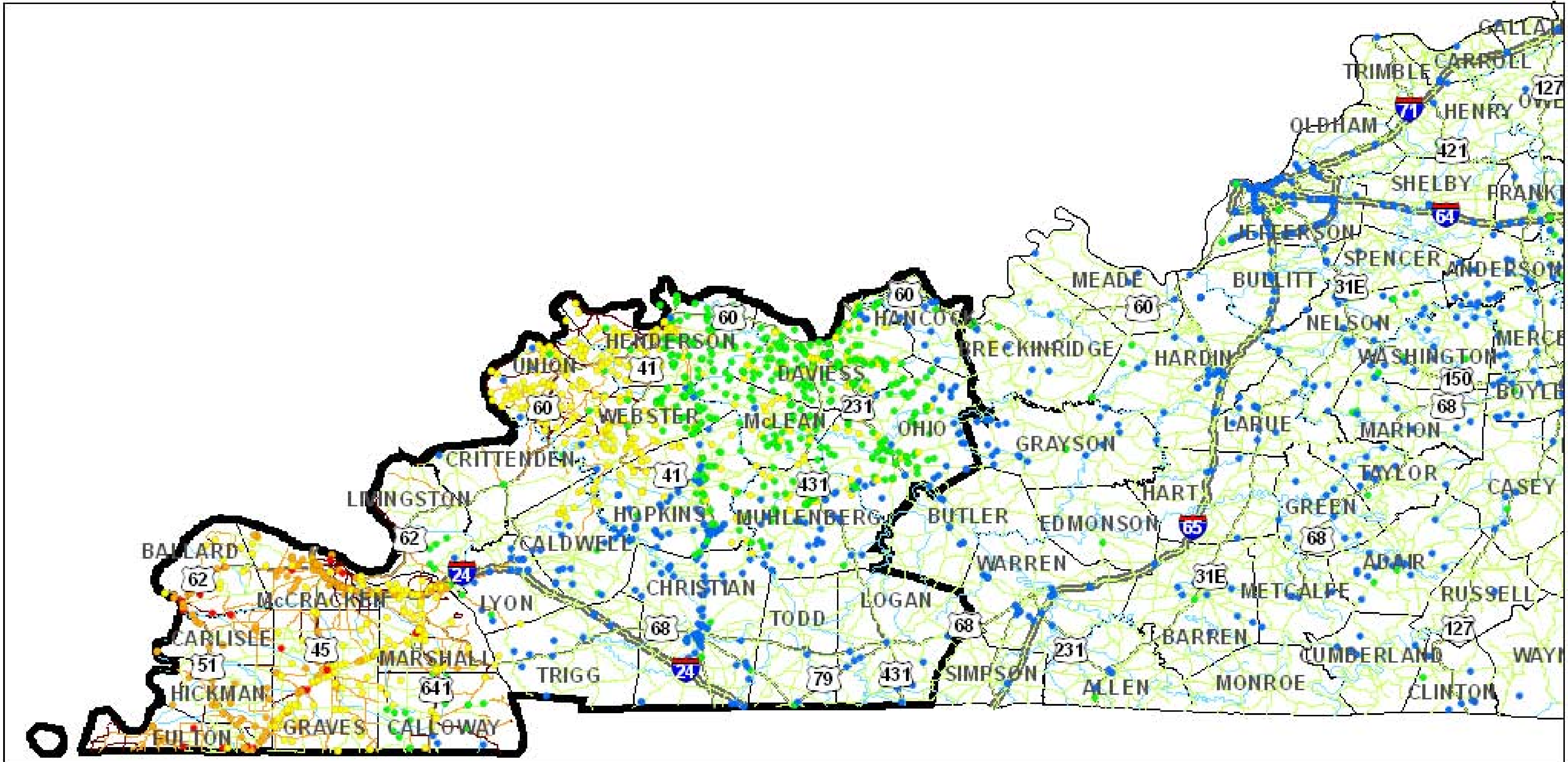
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

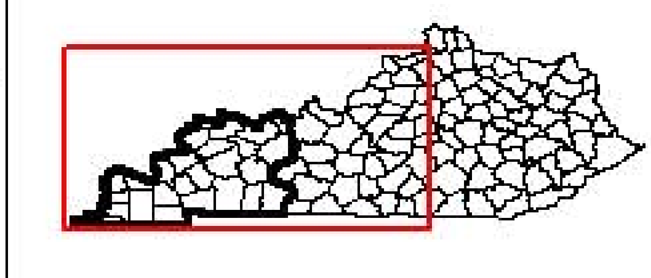
Highway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	25	13	6	Livingston	30	1	0
Caldwell	84	0	0	Logan	33	0	0
Calloway	36	2	0	Lyon	49	0	0
Carlisle	15	15	3	McCracken	80	62	11
Christian	202	0	0	McLean	64	0	0
Crittenden	19	0	0	Marshall	90	25	4
Daviess	233	0	0	Muhlenberg	127	0	0
Fulton	18	16	6	Ohio	190	0	0
Graves	122	41	16	Todd	22	0	0
Hancock	64	0	0	Trigg	38	0	0
Henderson	171	0	0	Union	114	0	0
Hickman	22	22	0	Webster	118	0	0
Hopkins	207	0	0		955		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Highway Bridge Damage At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Highway Segment Damage At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood

Rivers
US Routes
Critical Counties
Interstates

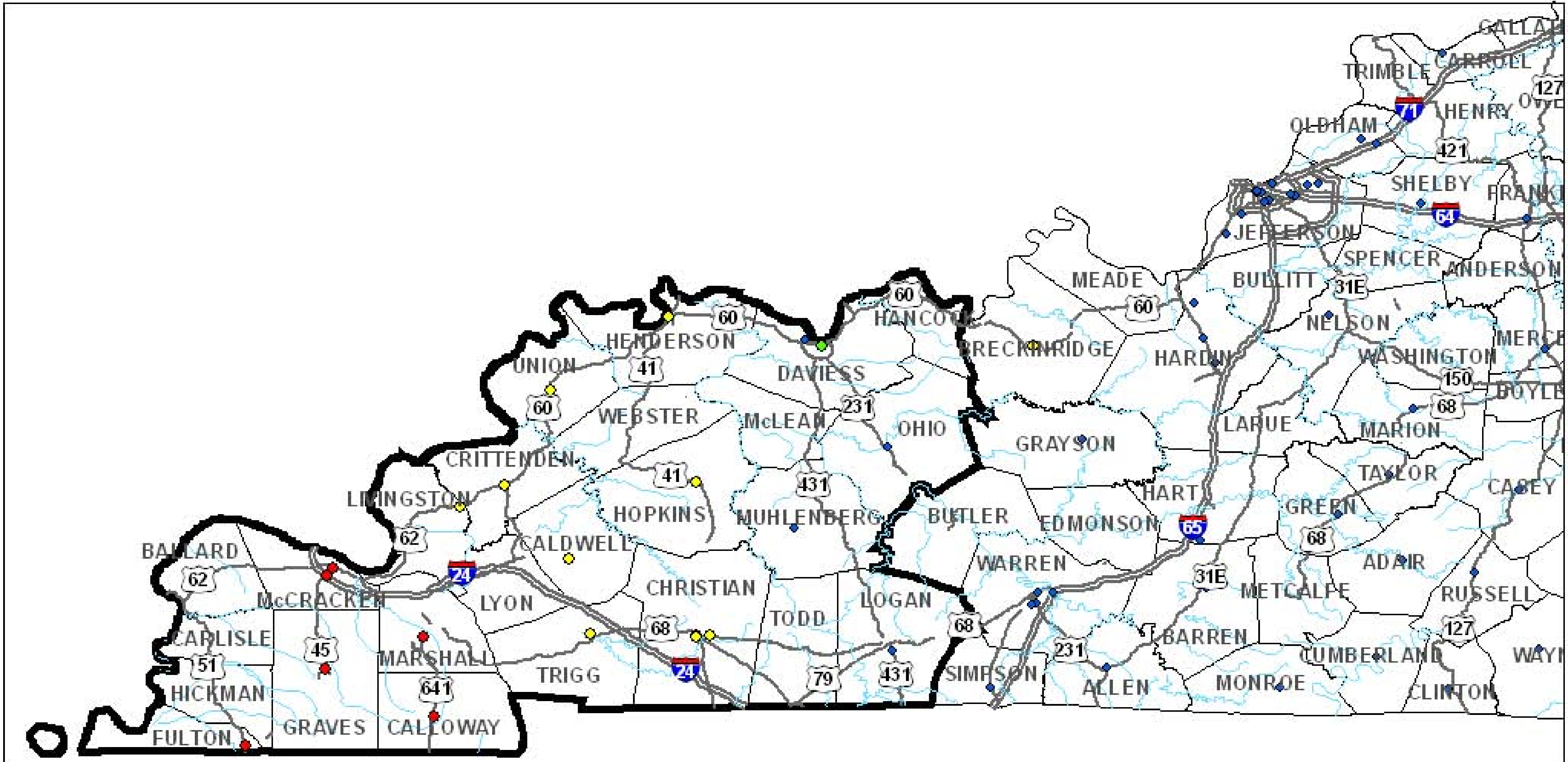
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

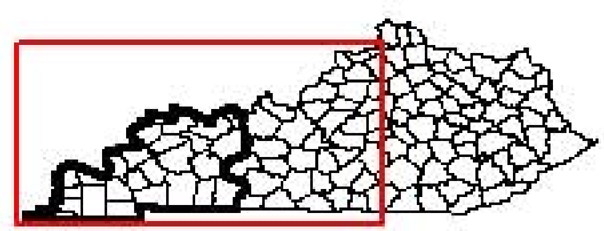
Hospital Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Caldwell	1	0	0
Calloway	1	1	0
Christian	3	0	0
Crittenden	1	0	0
Daviess	2	0	0
Fulton	1	1	0
Graves	1	1	1
Henderson	1	0	0
Hopkins	1	0	0
Livingston	1	0	0
Logan	1	0	0
McCracken	2	2	2
Marshall	1	1	1
Muhlenberg	1	0	0
Ohio	1	0	0
Trigg	1	0	0
Union	1	0	0
Ballard	0	0	0
Carlisle	0	0	0
Hancock	0	0	0
Hickman	0	0	0
Lyon	0	0	0
McLean	0	0	0
Todd	0	0	0
Webster	0	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Interstates
US Routes
Rivers

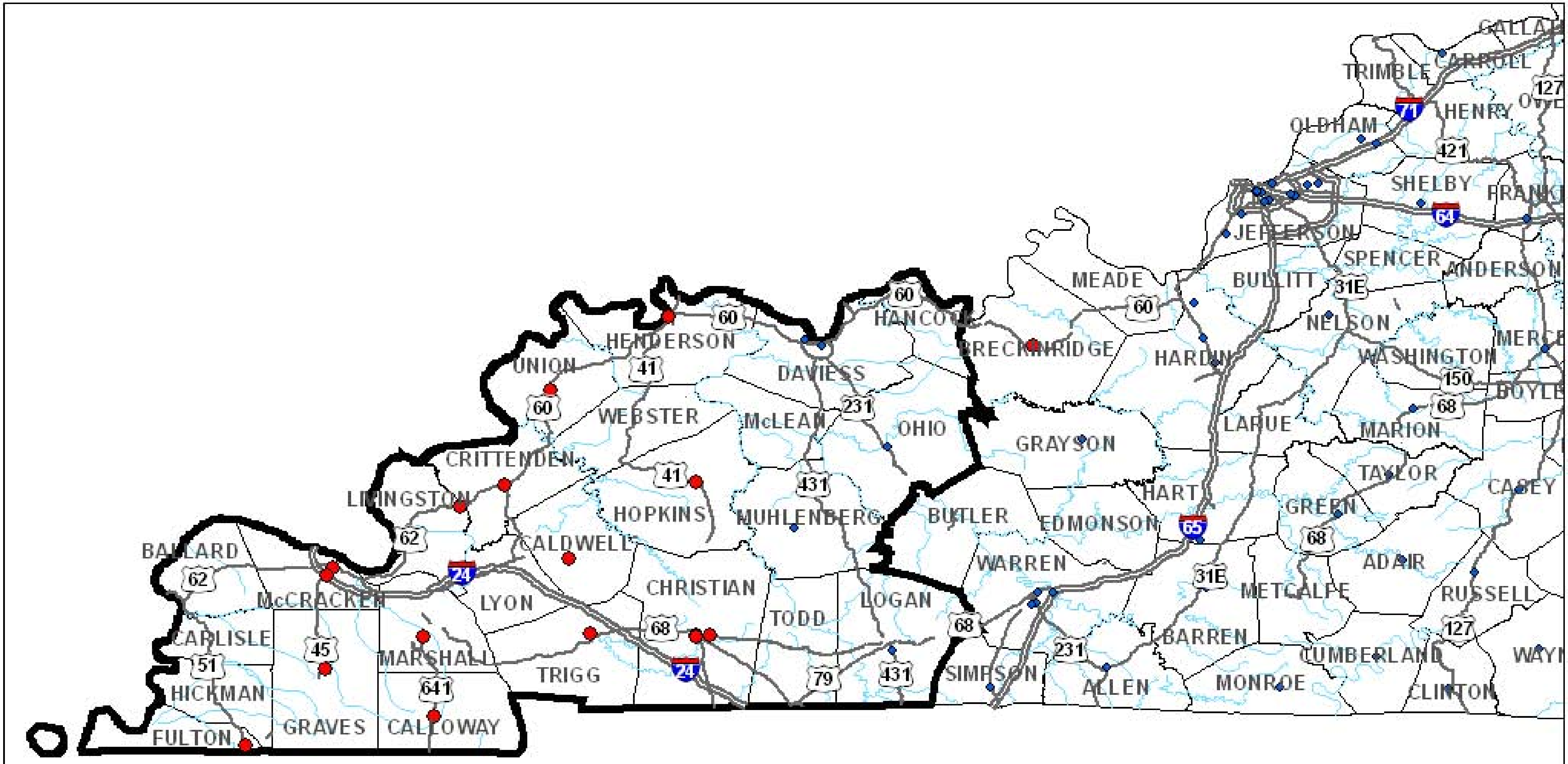
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

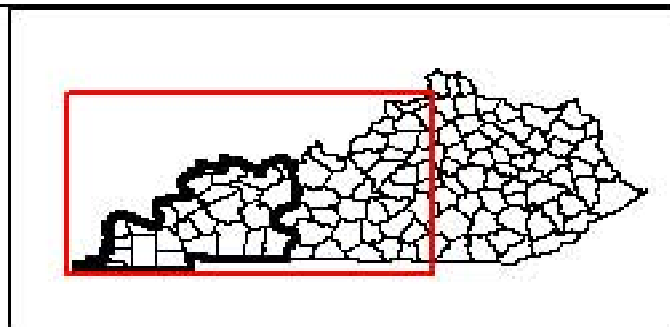
Hospital Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Ballard	0	0
Caldwell	0	1
Calloway	0	1
Carlisle	0	0
Christian	0	3
Crittenden	0	1
Daviess	2	2
Fulton	0	1
Graves	0	1
Hancock	0	0
Henderson	0	1
Hickman	0	0
Hopkins	0	1
Livingston	0	1
Logan	1	1
Lyon	0	0
Marshall	0	1
McCracken	0	2
McLean	0	0
Muhlenberg	1	1
Ohio	1	1
Todd	0	0
Trigg	0	1
Union	0	1
Webster	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Hospital Functionality
Day 1
- Not Functional
- Functional

US Routes
Interstates
Critical Counties
Rivers

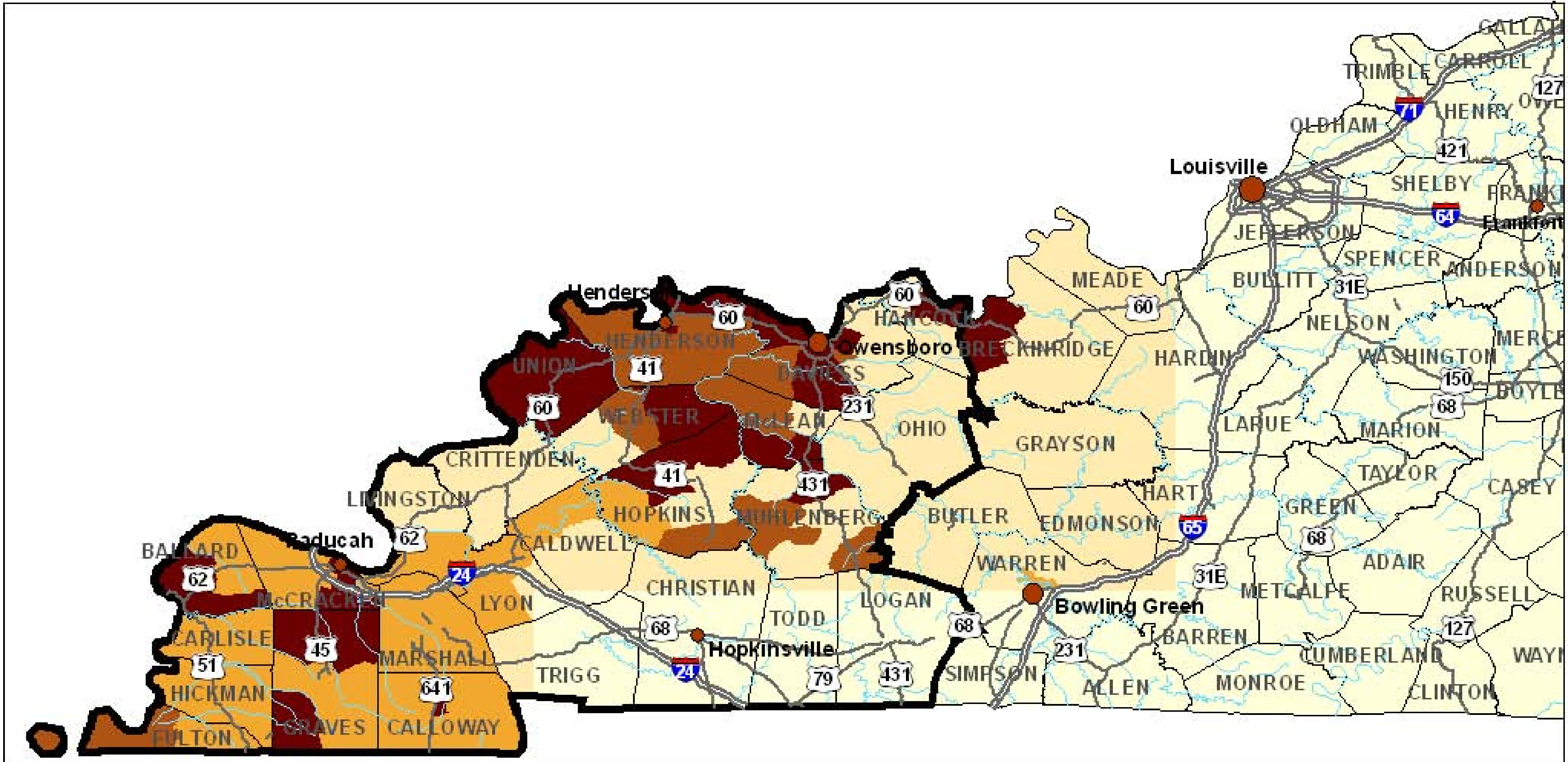
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

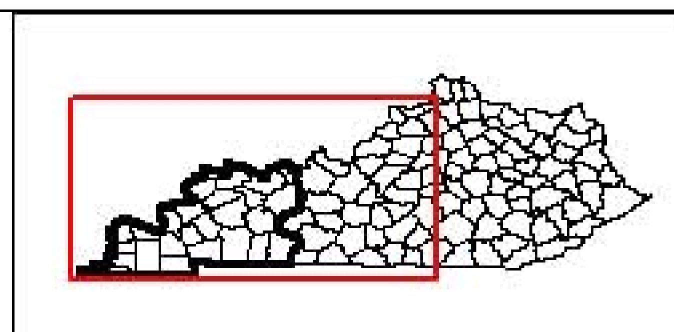
March 2008



State of Kentucky - Critical Counties (25)

County	Minimum Susceptibility	Maximum Susceptibility
Ballard	Low	Very High
Caldwell	Unknown	Low
Calloway	Low	Very High
Carlisle	Low	Very High
Christian	Unknown	None
Crittenden	None	None
Daviess	None	Very High
Fulton	Low	Moderate
Graves	Low	Very High
Hancock	None	Very High
Henderson	Moderate	Very High
Hickman	Low	Low
Hopkins	None	Very High

County	Minimum Susceptibility	Maximum Susceptibility
Livingston	None	Low
Logan	Unknown	None
Lyon	Unknown	Low
McCracken	Low	Very High
McLean	None	Very High
Marshall	Low	Low
Muhlenberg	None	Very High
Ohio	None	None
Todd	Unknown	None
Trigg	Unknown	None
Union	Very High	Very High
Webster	None	Very High



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Liquefaction Susceptibility

- Unknown
- None
- Low
- Moderate
- Very High

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

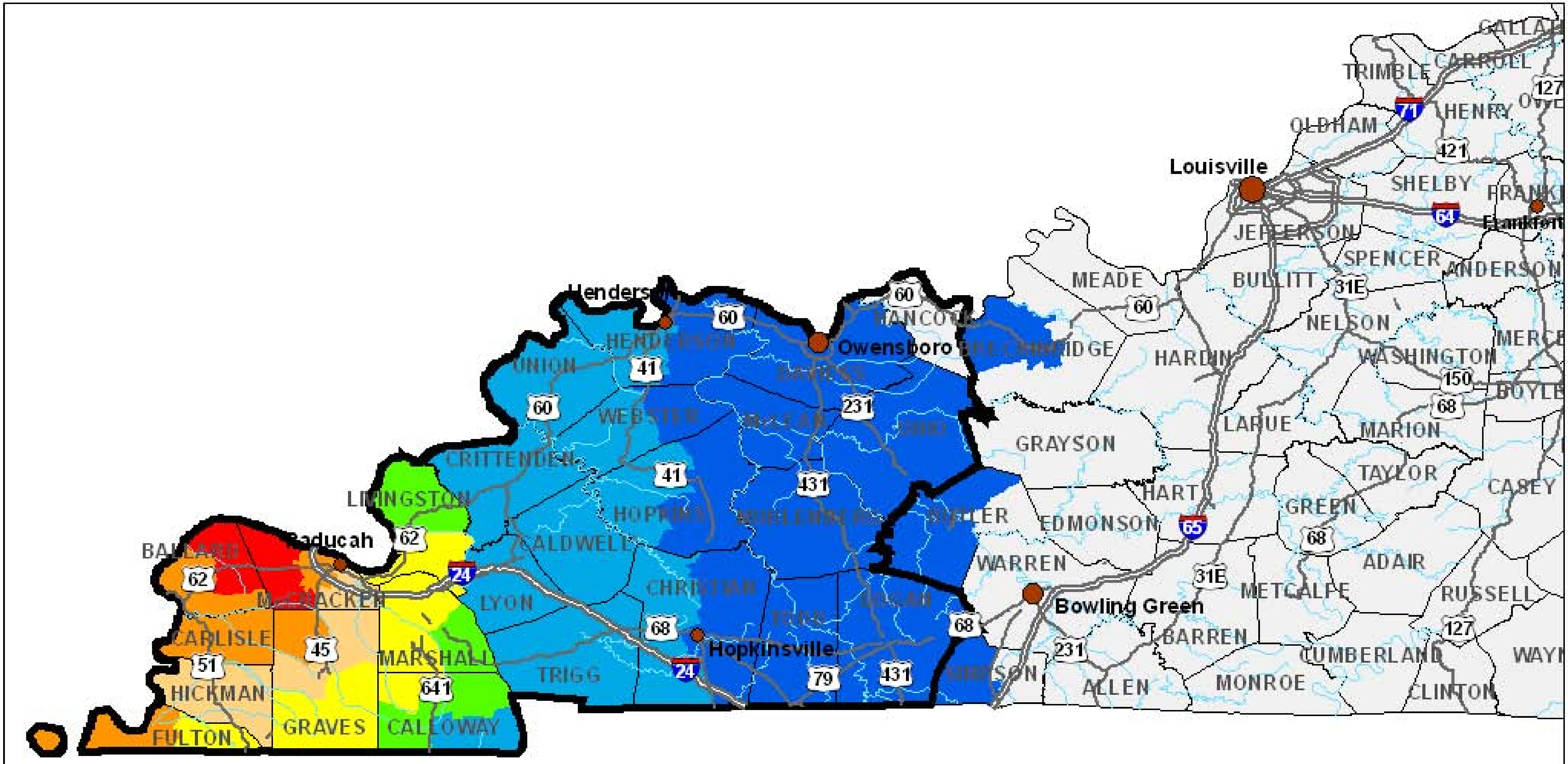
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

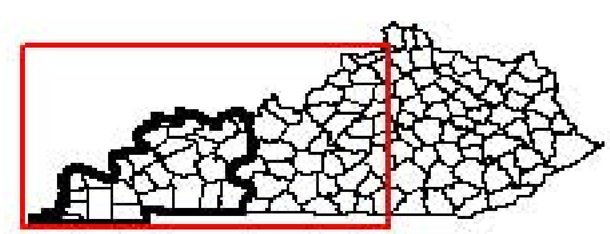
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Max. MM	County	Max. MM	County	Max. MM
Ballard	XII	Hancock	< VI	Marshall	IX
Caldwell	VII	Henderson	VII	Muhlenberg	VI
Calloway	IX	Hickman	X	Ohio	VI
Carlisle	XI	Hopkins	VII	Todd	VI
Christian	VII	Livingston	IX	Trigg	VII
Crittenden	VII	Logan	VI	Union	VII
Daviess	VI	Lyon	VII	Webster	VII
Fulton	XI	McCracken	XII		
Graves	XI	McLean	VI		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

US Routes — Rivers — Interstates — Critical Counties

0 10 20 40 60

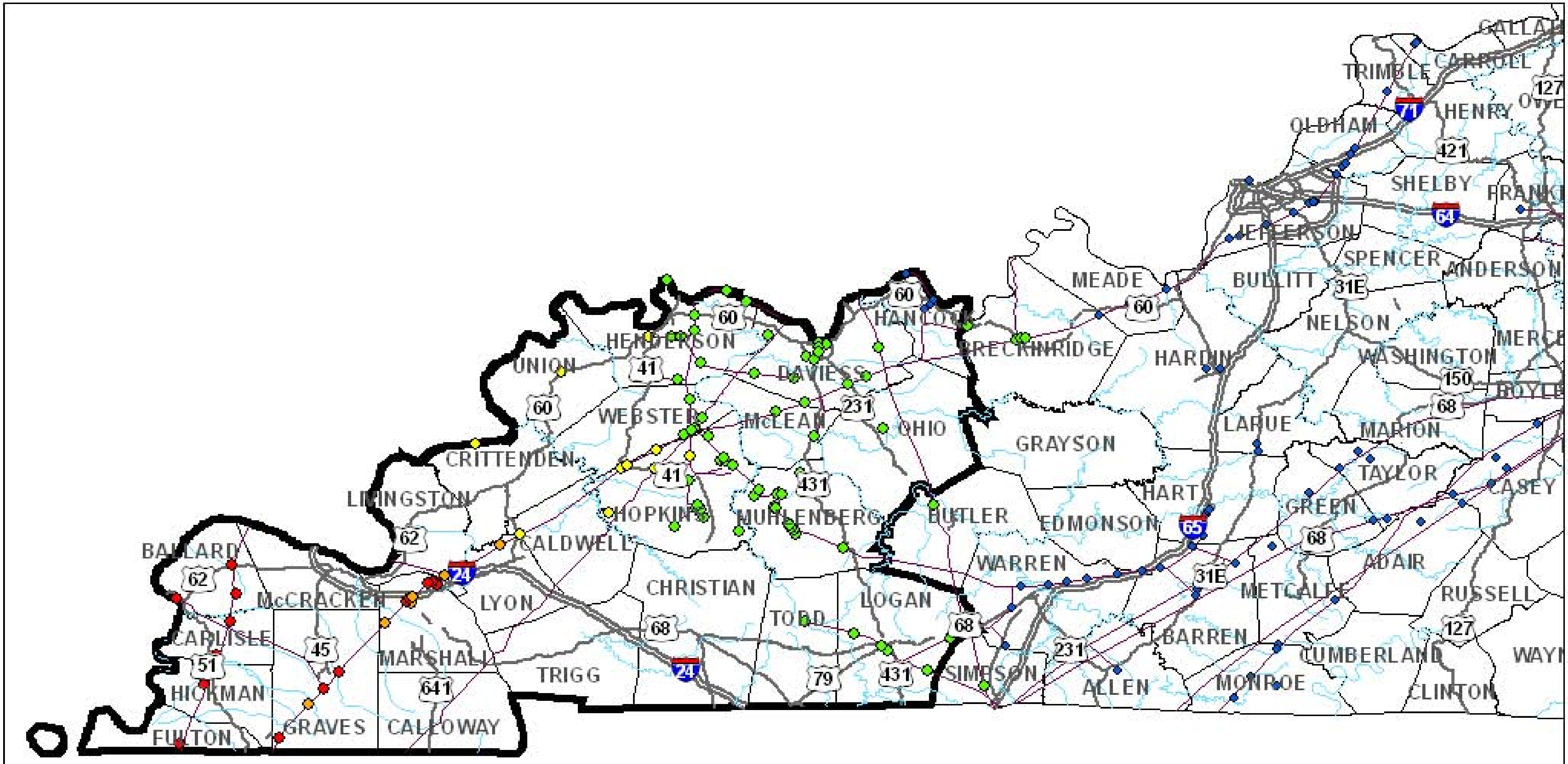
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

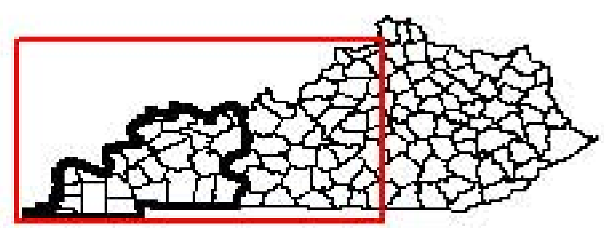
Natural Gas Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	0	0	0
Caldwell	1	0	0
Calloway	1	1	0
Carlisle	0	0	0
Christian	3	0	0
Crittenden	1	0	0
Daviess	2	0	0
Fulton	1	1	0
Graves	1	1	1
Hancock	0	0	0
Henderson	1	0	0
Hickman	0	0	0
Hopkins	1	0	0
Livingston	1	0	0
Logan	1	0	0
Lyon	0	0	0
Marshall	1	1	1
McCracken	2	2	2
McLean	0	0	0
Muhlenberg	1	0	0
Ohio	1	0	0
Todd	0	0	0
Trigg	1	0	0
Union	1	0	0
Webster	0	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Natural Gas Factility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers
- Natural Gas Lines

0 10 20 40 60

Miles

Mid-America Earthquake Center

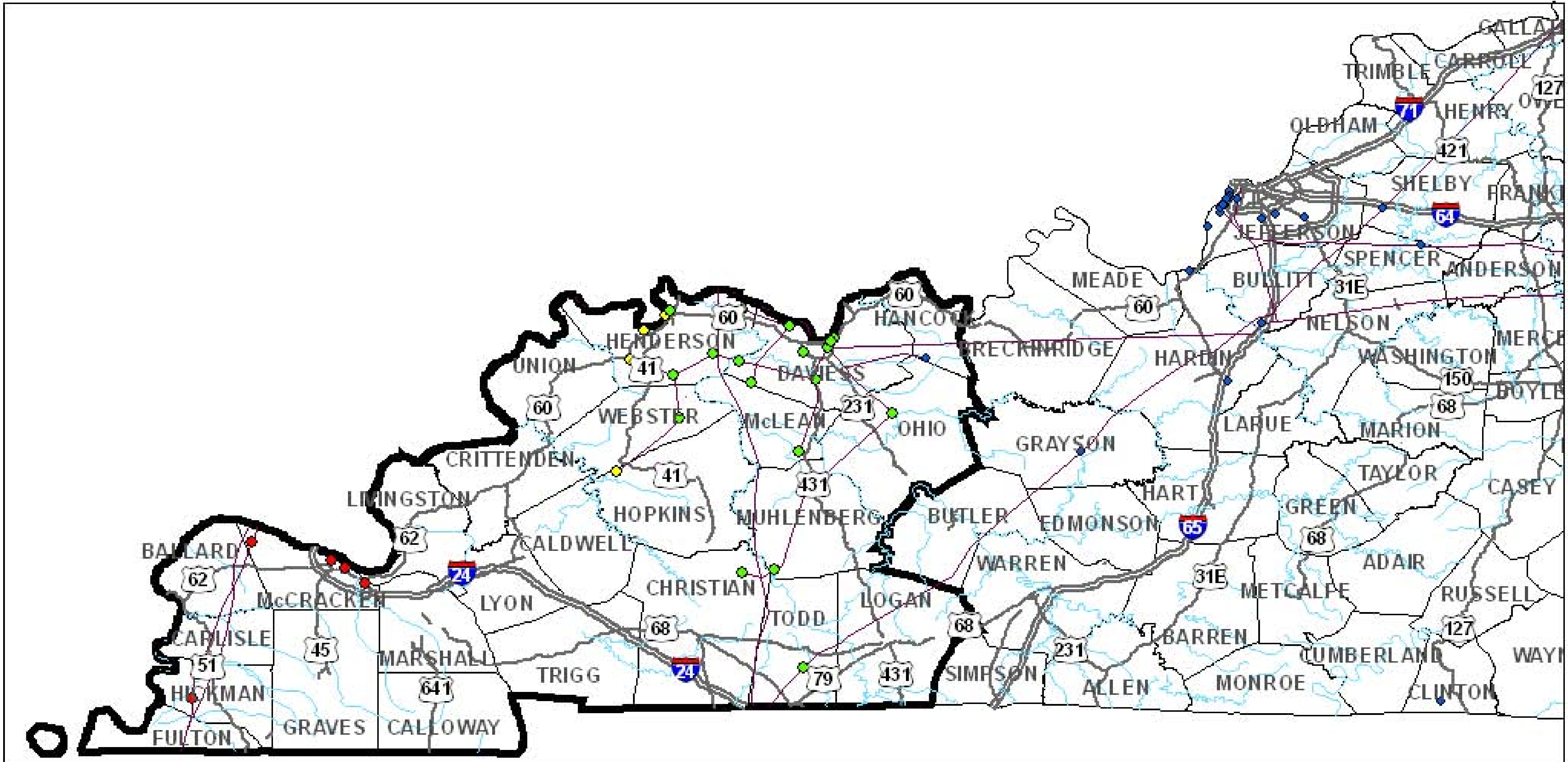
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

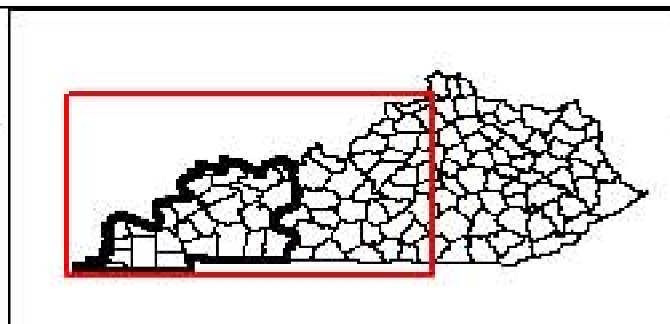
Oil Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	0	0	0
Caldwell	0	0	0
Calloway	0	0	0
Carlisle	0	0	0
Christian	1	0	0
Crittenden	0	0	0
Daviess	9	0	0
Fulton	0	0	0
Graves	0	0	0
Hancock	1	0	0
Henderson	7	0	0
Hickman	1	1	0
Hopkins	1	0	0
Livingston	0	0	0
Logan	0	0	0
Lyon	0	0	0
Marshall	0	0	0
McCracken	5	5	1
McLean	1	0	0
Muhlenberg	2	0	0
Ohio	1	0	0
Todd	1	0	0
Trigg	0	0	0
Union	0	0	0
Webster	1	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers
- Major Oil Lines

0 10 20 40 60

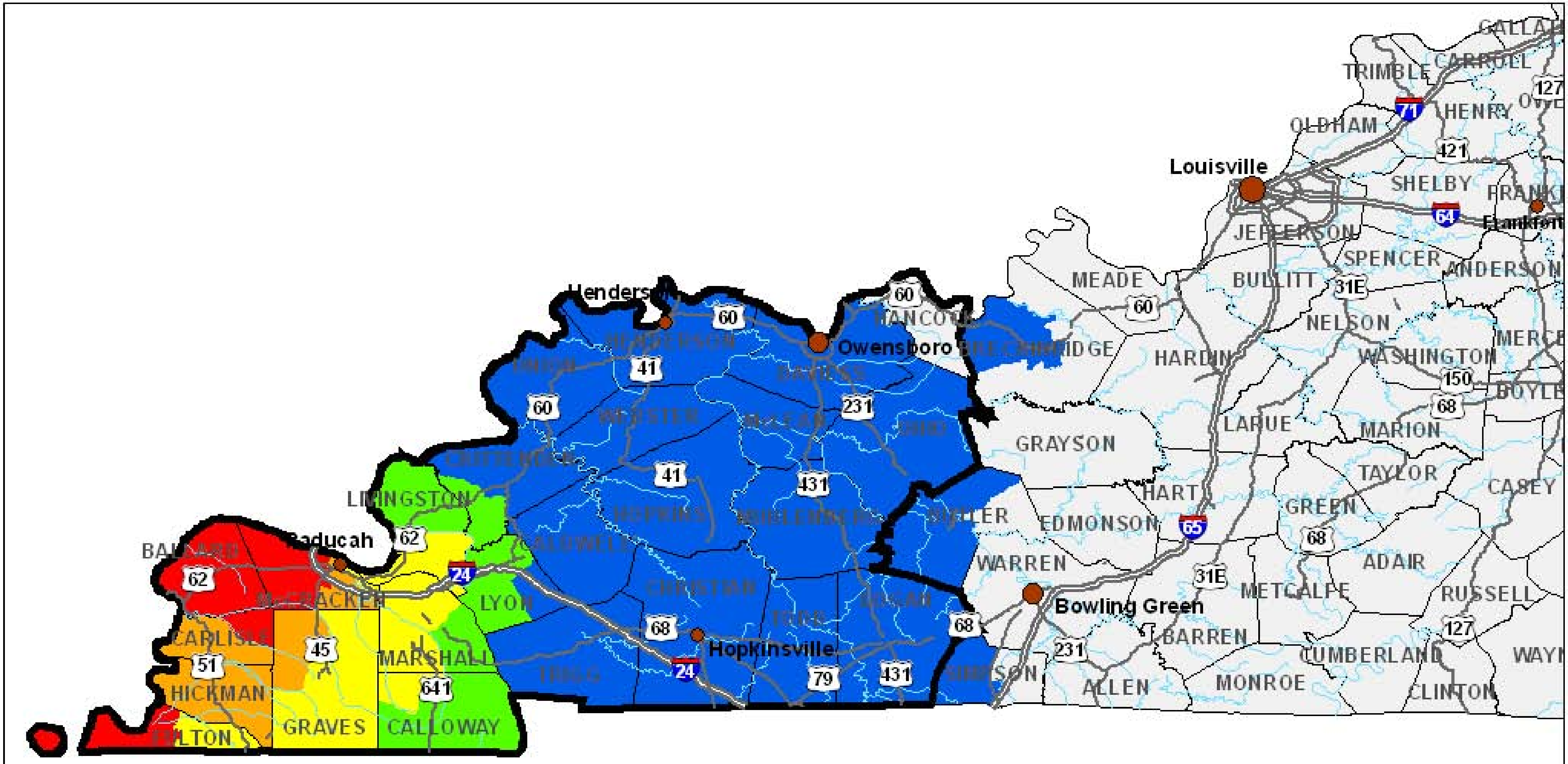
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

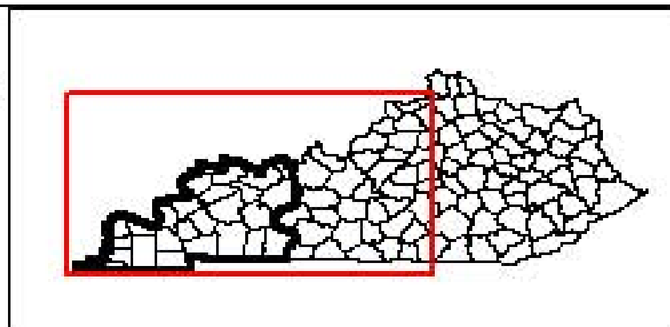
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Min. PGA	Max. PGA
Ballard	1.04	1.25
Caldwell	0.25	0.25
Calloway	0.34	0.55
Carlisle	0.94	1.14
Christian	0.15	0.25
Crittenden	0.25	0.34
Daviess	0.15	0.15
Fulton	0.64	1.04
Graves	0.55	0.94
Hancock	0.06	0.06
Henderson	0.15	0.25
Hickman	0.85	0.85
Hopkins	0.15	0.25
Livingston	0.44	0.64
Logan	0.15	0.15
Lyon	0.25	0.34
McCracken	0.75	1.25
McLean	0.15	0.15
Marshall	0.44	0.64
Muhlenberg	0.15	0.15
Ohio	0.15	0.15
Todd	0.15	0.15
Trigg	0.25	0.25
Union	0.25	0.25
Webster	0.15	0.25



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Legend

Peak Ground Acceleration (g)

- 0.05 - 0.1
- 0.1 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1.0
- 1.0 - 1.25

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

- US Routes
- Interstates
- Rivers
- Critical Counties

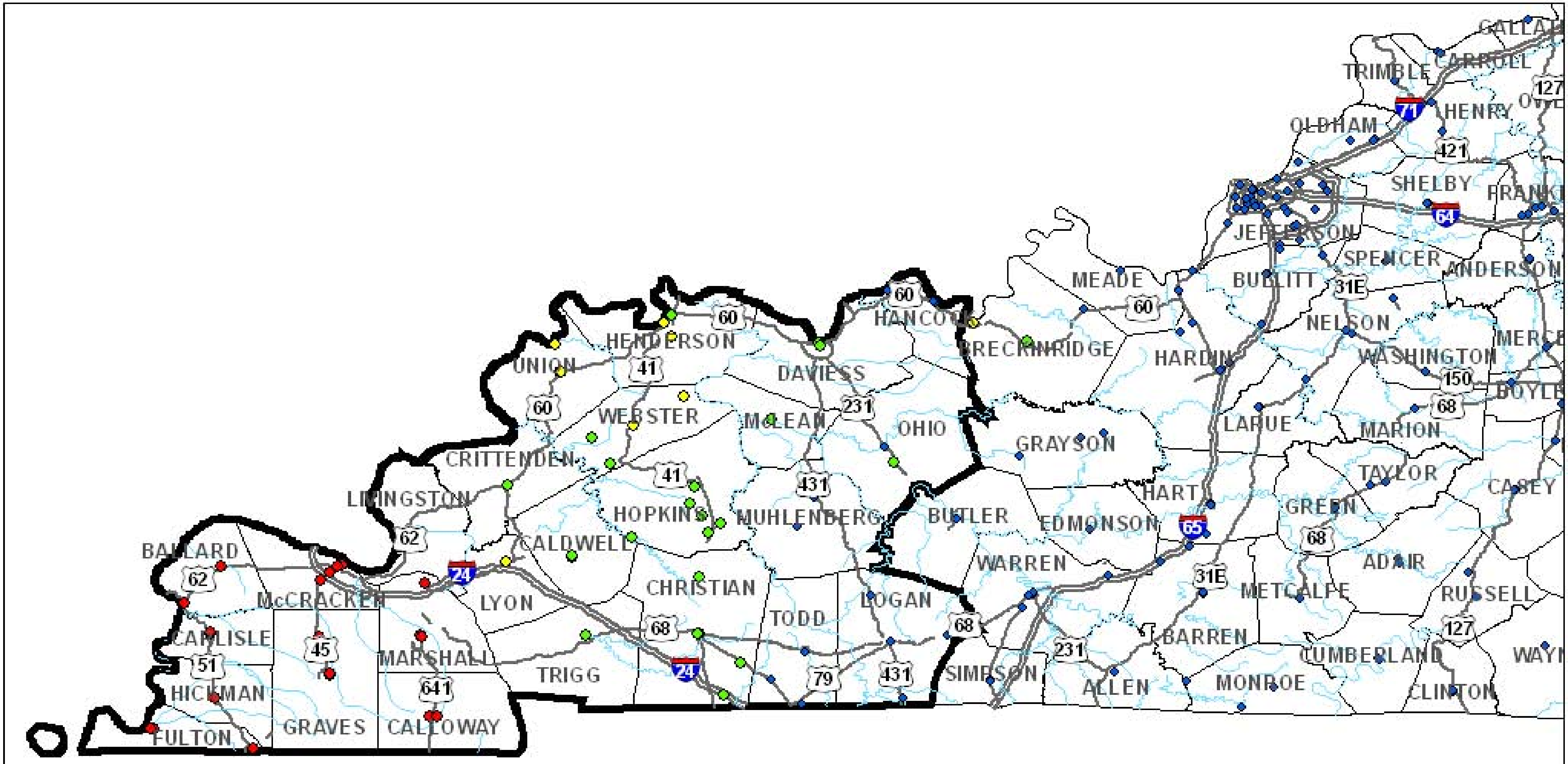
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Police Station Damage - New Madrid Seismic Zone: M7.7 Event

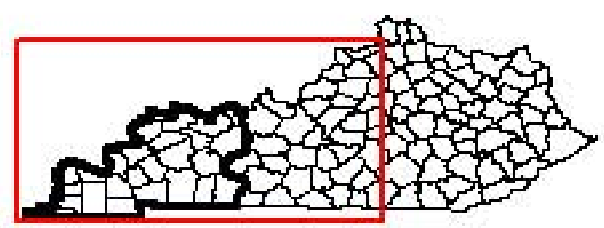
March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	2	2	2
Caldwell	2	0	0
Calloway	3	3	0
Carlisle	2	2	2
Christian	6	0	0
Crittenden	2	0	0
Daviess	2	0	0
Fulton	3	3	3
Graves	3	3	3
Hancock	3	0	0
Henderson	3	0	0
Hickman	2	2	2
Hopkins	7	0	0

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Livingston	1	1	0
Logan	5	0	0
Lyon	2	0	0
McCracken	4	4	4
McLean	2	0	0
Marshall	3	3	3
Muhlenberg	3	0	0
Ohio	3	0	0
Todd	4	0	0
Trigg	2	0	0
Union	4	0	0
Webster	4	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers

0 10 20 40 60

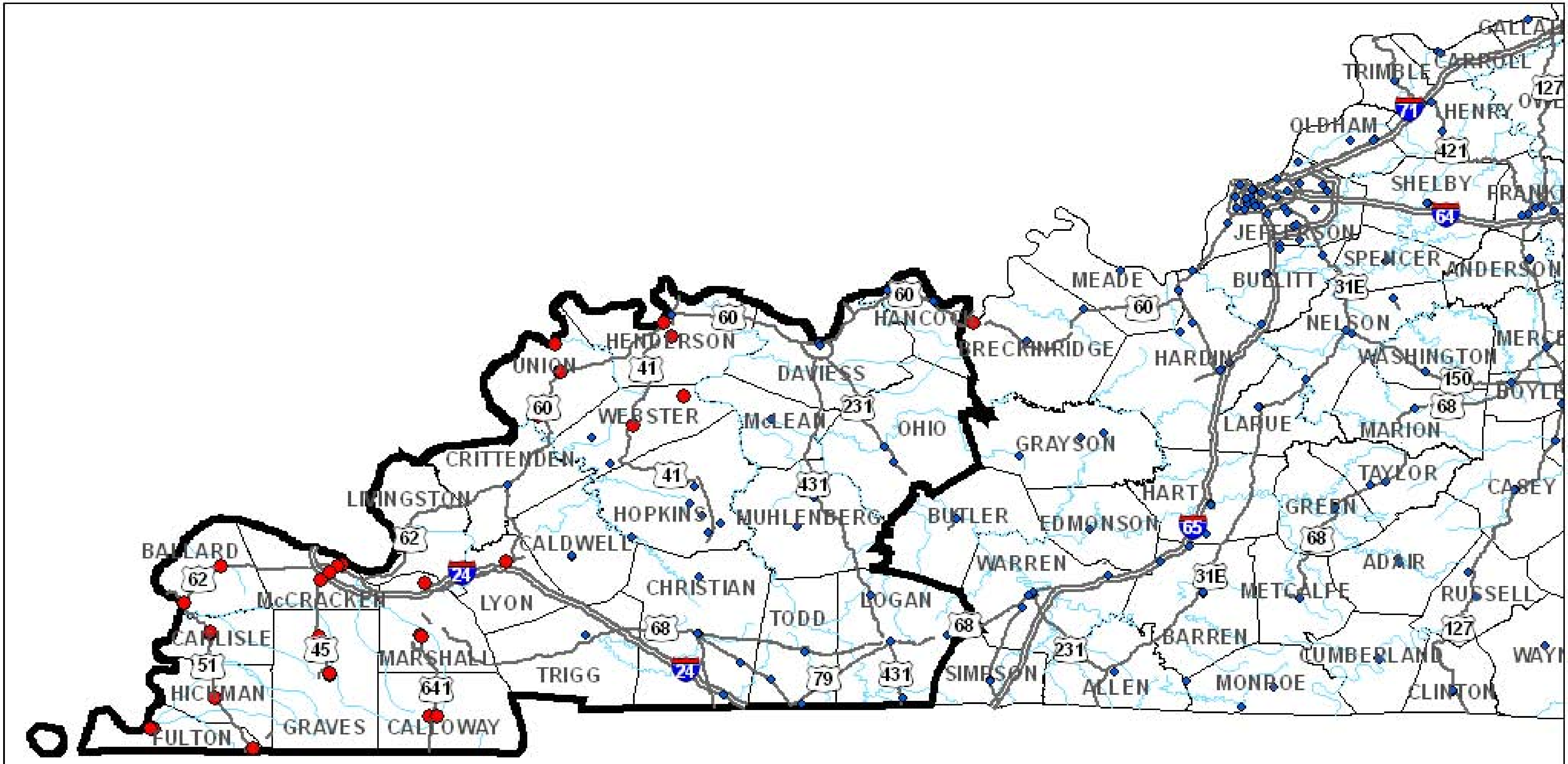
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

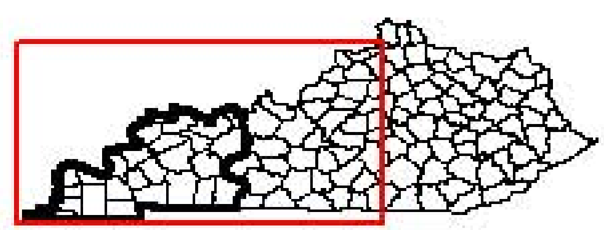
Police Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Ballard	0	2
Caldwell	2	2
Calloway	0	3
Carlisle	0	2
Christian	6	6
Crittenden	2	2
Daviess	2	2
Fulton	0	3
Graves	0	3
Hancock	3	3
Henderson	1	3
Hickman	0	2
Hopkins	7	7
Livingston	0	1
Logan	5	5
Lyon	0	2
McCracken	0	4
McLean	2	2
Marshall	0	3
Muhlenberg	3	3
Ohio	3	3
Todd	4	4
Trigg	2	2
Union	0	4
Webster	2	4



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Police Station Functionality

Day 1

- Not Functional
- Functional

US Routes
Interstates
Critical Counties
Rivers

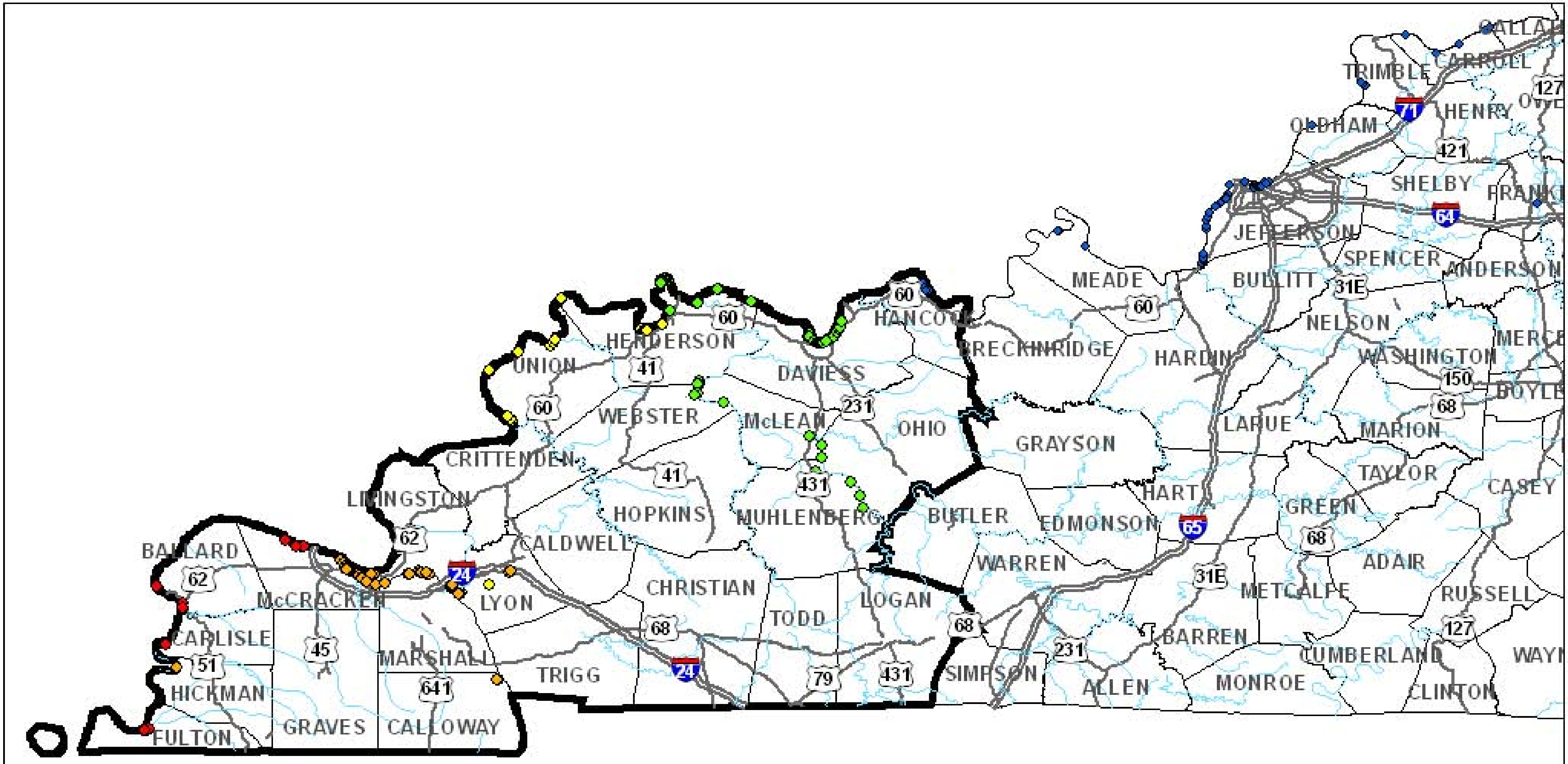
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

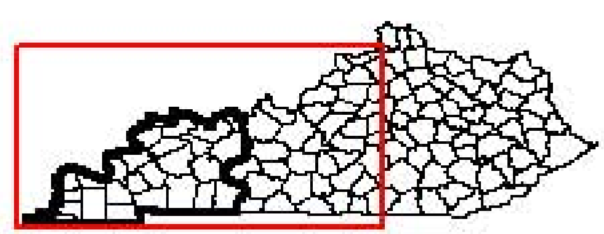
Port Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	3	3	2	Livingston	12	12	0
Caldwell	0	0	0	Logan	0	0	0
Calloway	2	2	0	Lyon	4	3	0
Carlisle	2	2	0	Marshall	13	13	0
Christian	0	0	0	McCracken	41	41	4
Crittenden	0	0	0	McLean	5	0	0
Daviess	25	0	0	Muhlenberg	4	0	0
Fulton	8	8	8	Ohio	4	0	0
Graves	0	0	0	Todd	0	0	0
Hancock	4	0	0	Trigg	0	0	0
Henderson	25	0	0	Union	8	0	0
Hickman	2	2	0	Webster	2	0	0
Hopkins	0	0	0				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Interstates
US Routes
Rivers

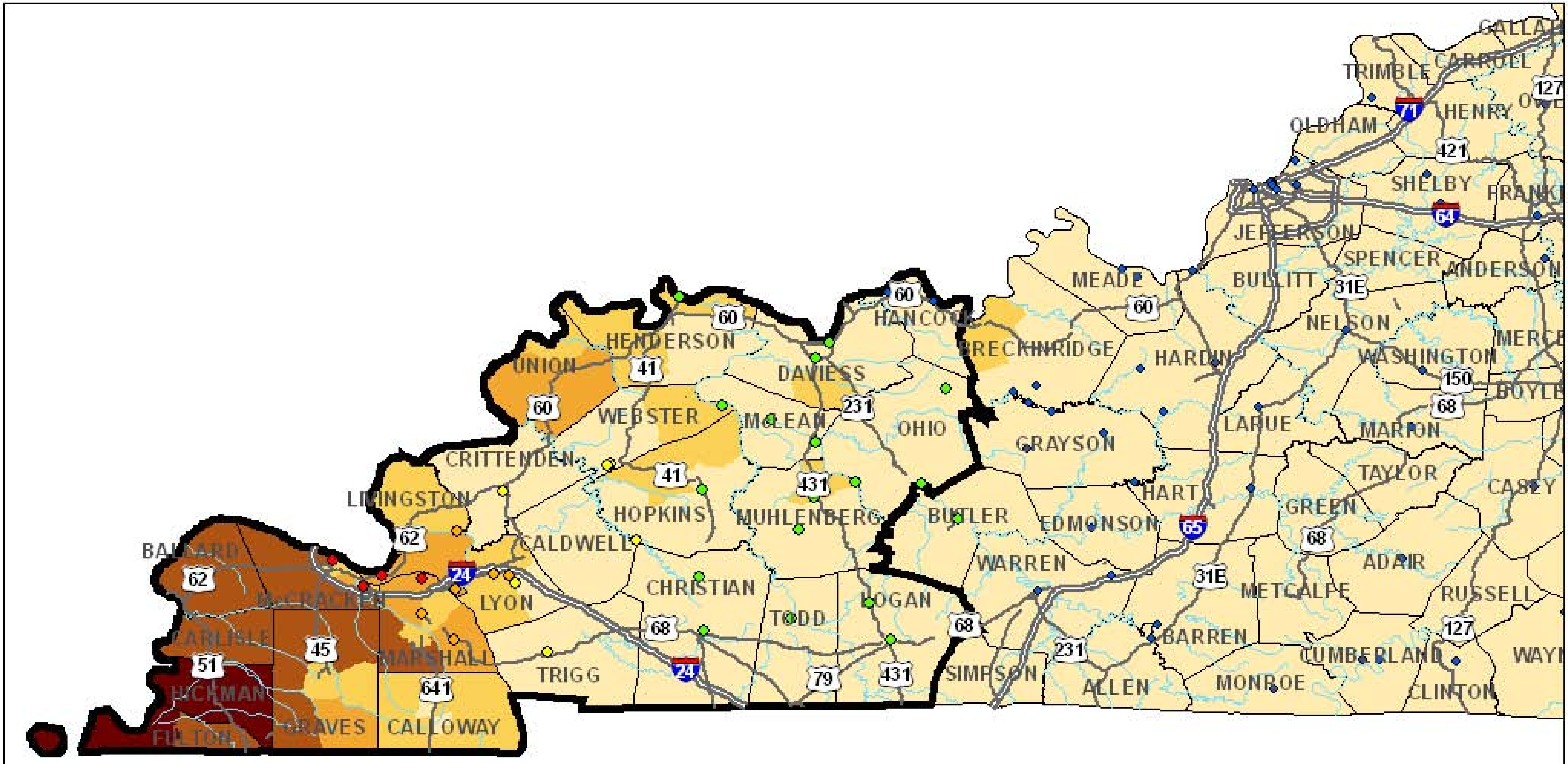
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

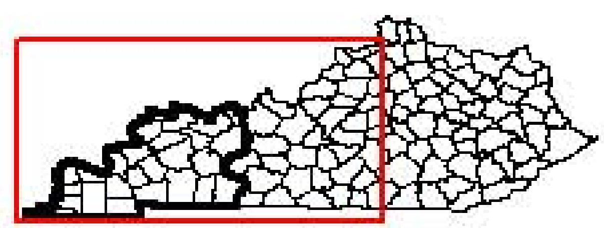
Potable Water System Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	0	0	0
Caldwell	0	0	0
Calloway	0	0	0
Carlisle	0	0	0
Christian	2	0	0
Crittenden	1	0	0
Daviess	2	0	0
Fulton	0	0	0
Graves	0	0	0
Hancock	2	0	0
Henderson	1	0	0
Hickman	0	0	0
Hopkins	2	0	0
Livingston	3	3	0
Logan	2	0	0
Lyon	3	2	0
McCracken	3	3	0
McLean	2	0	0
Marshall	3	3	0
Muhlenberg	2	0	0
Ohio	3	0	0
Todd	1	0	0
Trigg	1	0	0
Union	0	0	0
Webster	3	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Potable Water Facility Damage At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Potable Water Distribution Lines No. of Leaks
- 0 - 10
- 11 - 50
- 51 - 100
- 101 - 500
- 501 - 1,000

US Routes
Interstates
Critical Counties
Rivers

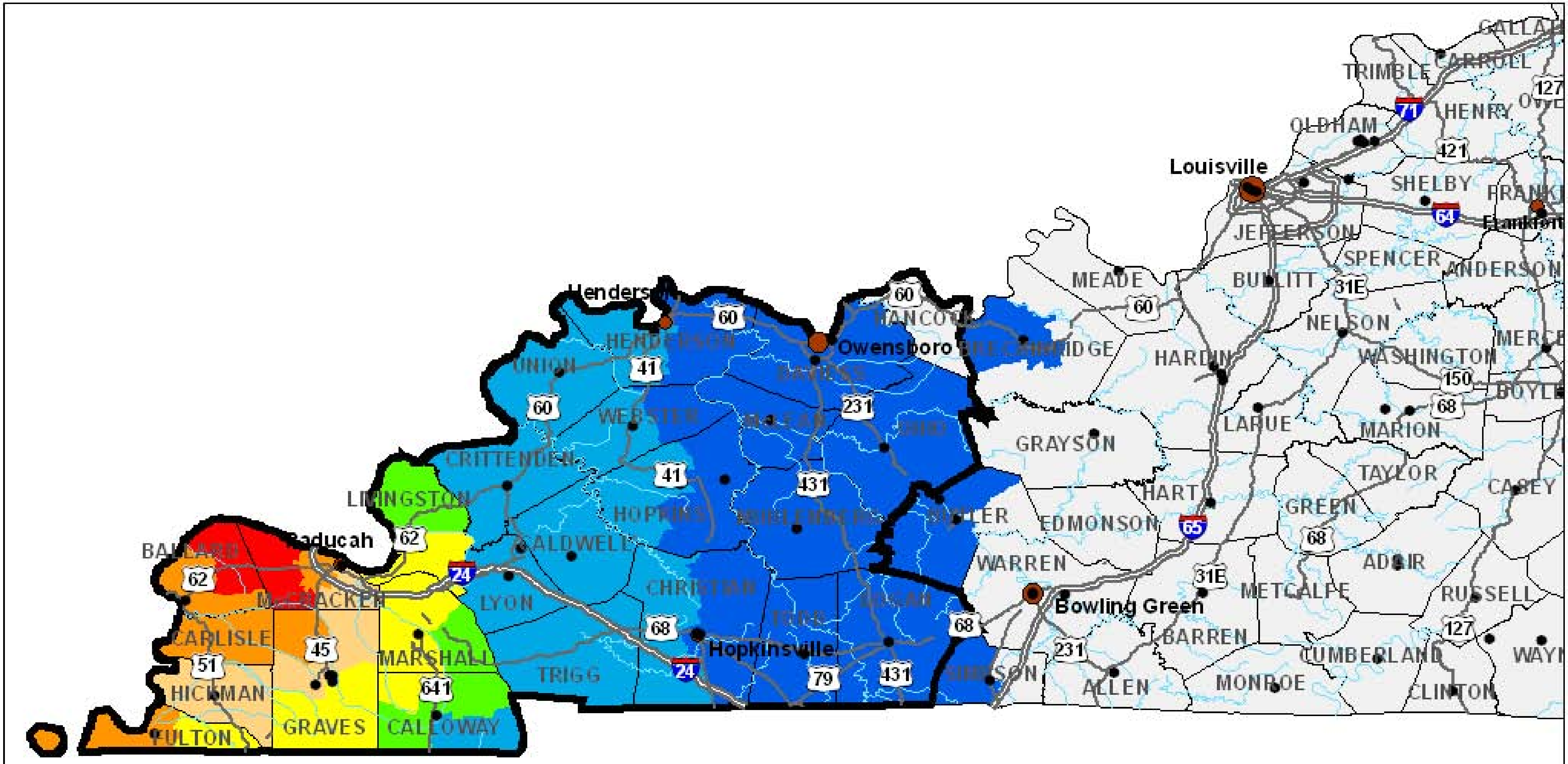
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

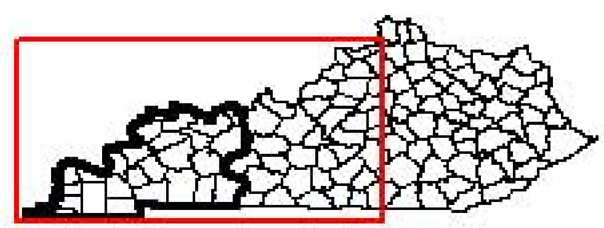
Prisons - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Facilities	County	No. of Facilities	County	No. of Facilities
Ballard	1	Hancock	0	McLean	1
Caldwell	1	Henderson	1	Muhlenberg	2
Calloway	1	Hickman	1	Ohio	1
Carlisle	0	Hopkins	2	Todd	1
Christian	2	Livingston	1	Trigg	0
Crittenden	1	Logan	1	Union	1
Daviess	2	Lyon	2	Webster	1
Fulton	1	Marshall	1		
Graves	4	McCracken	1		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

- Prisons

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

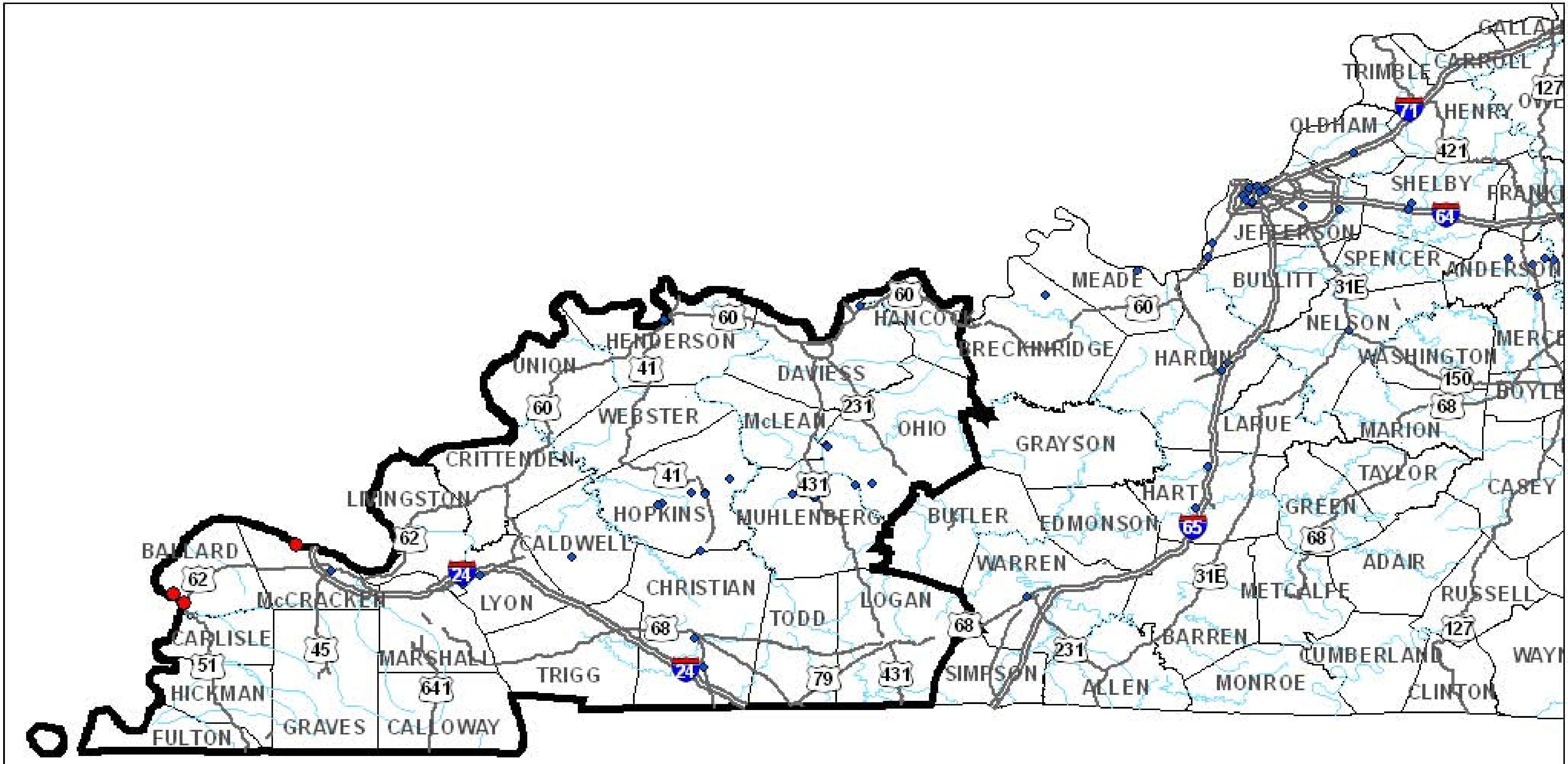
- US Routes
- Rivers
- Interstates
- Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

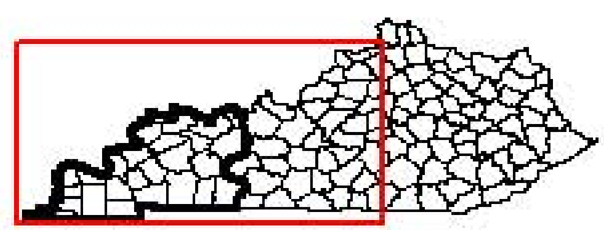
Railway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities	County	No. of Functional Facilities	Total No. of Facilities
Ballard	0	2	Livingston	0	0
Caldwell	1	1	Logan	0	0
Calloway	0	0	Lyon	3	3
Carlisle	0	0	Marshall	0	0
Christian	3	3	McCracken	1	2
Crittenden	0	0	McLean	0	0
Daviess	1	1	Muhlenberg	5	5
Fulton	0	0	Ohio	3	3
Graves	0	0	Todd	0	0
Hancock	2	2	Trigg	0	0
Henderson	6	6	Union	0	0
Hickman	0	0	Webster	0	0
Hopkins	7	7			



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Railway Bridge Functionality

Day 1

- Not Functional
- Functional

US Routes

Interstates

Critical Counties

Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

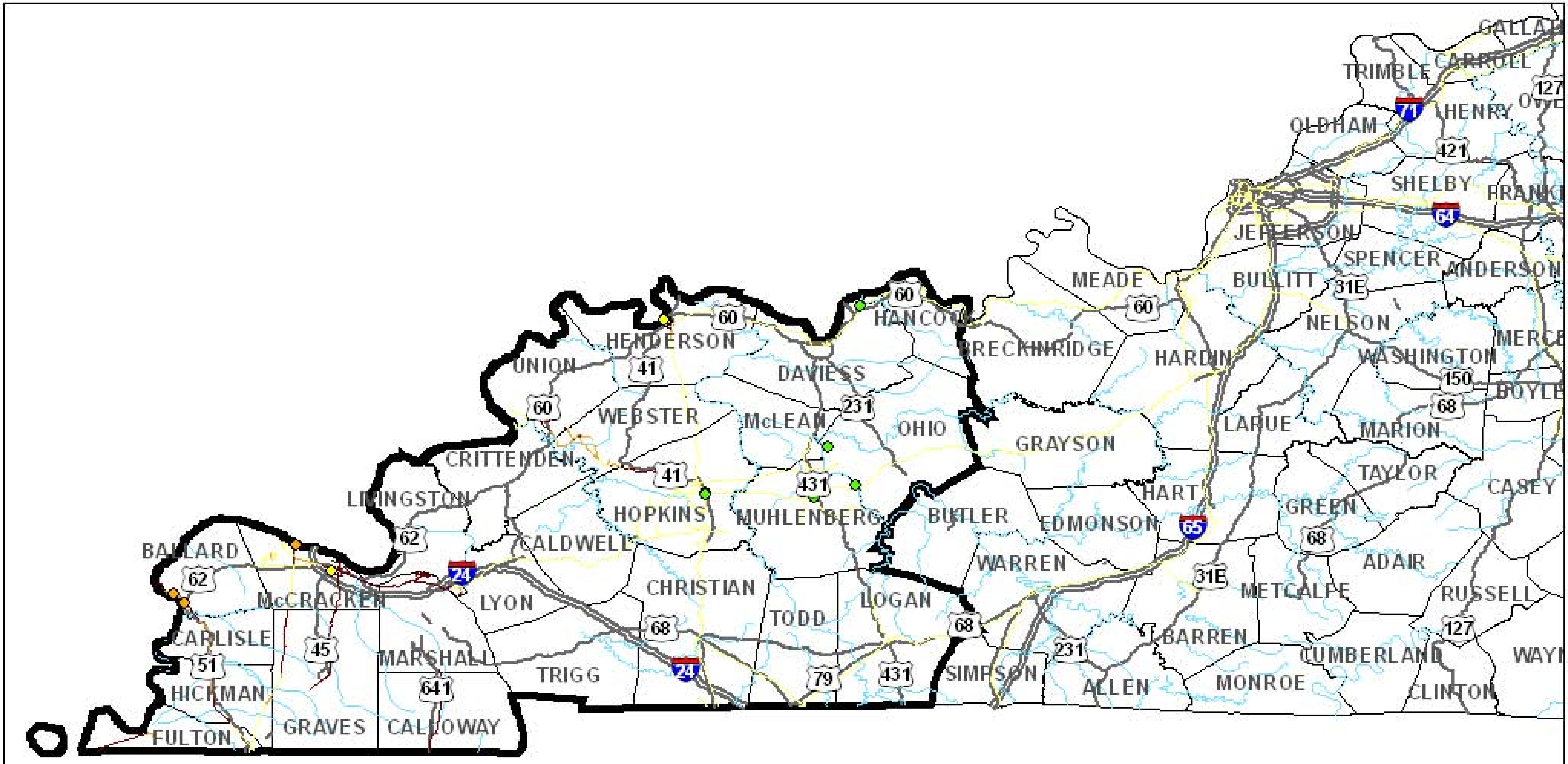
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

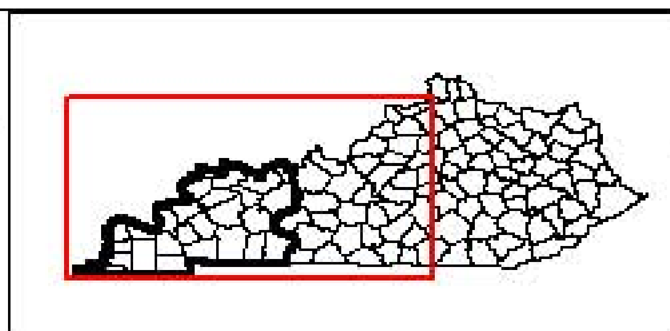
Railway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	2	2	0
Caldwell	1	0	0
Calloway	0	0	0
Carlisle	0	0	0
Christian	3	0	0
Crittenden	0	0	0
Daviess	1	0	0
Fulton	0	0	0
Graves	0	0	0
Hancock	2	0	0
Henderson	6	0	0
Hickman	0	0	0
Hopkins	7	0	0
Livingston	0	0	0
Logan	0	0	0
Lyon	3	0	0
Marshall	0	0	0
McCracken	2	1	0
McLean	0	0	0
Muhlenberg	5	0	0
Ohio	3	0	0
Todd	0	0	0
Trigg	0	0	0
Union	0	0	0
Webster	0	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Railway Bridge Damage At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Railway Segment Damage At Least Moderate
- Highly Unlikely
- Unlikely
- Moderate Likelihood

Rivers
US Routes
Critical Counties
Interstates

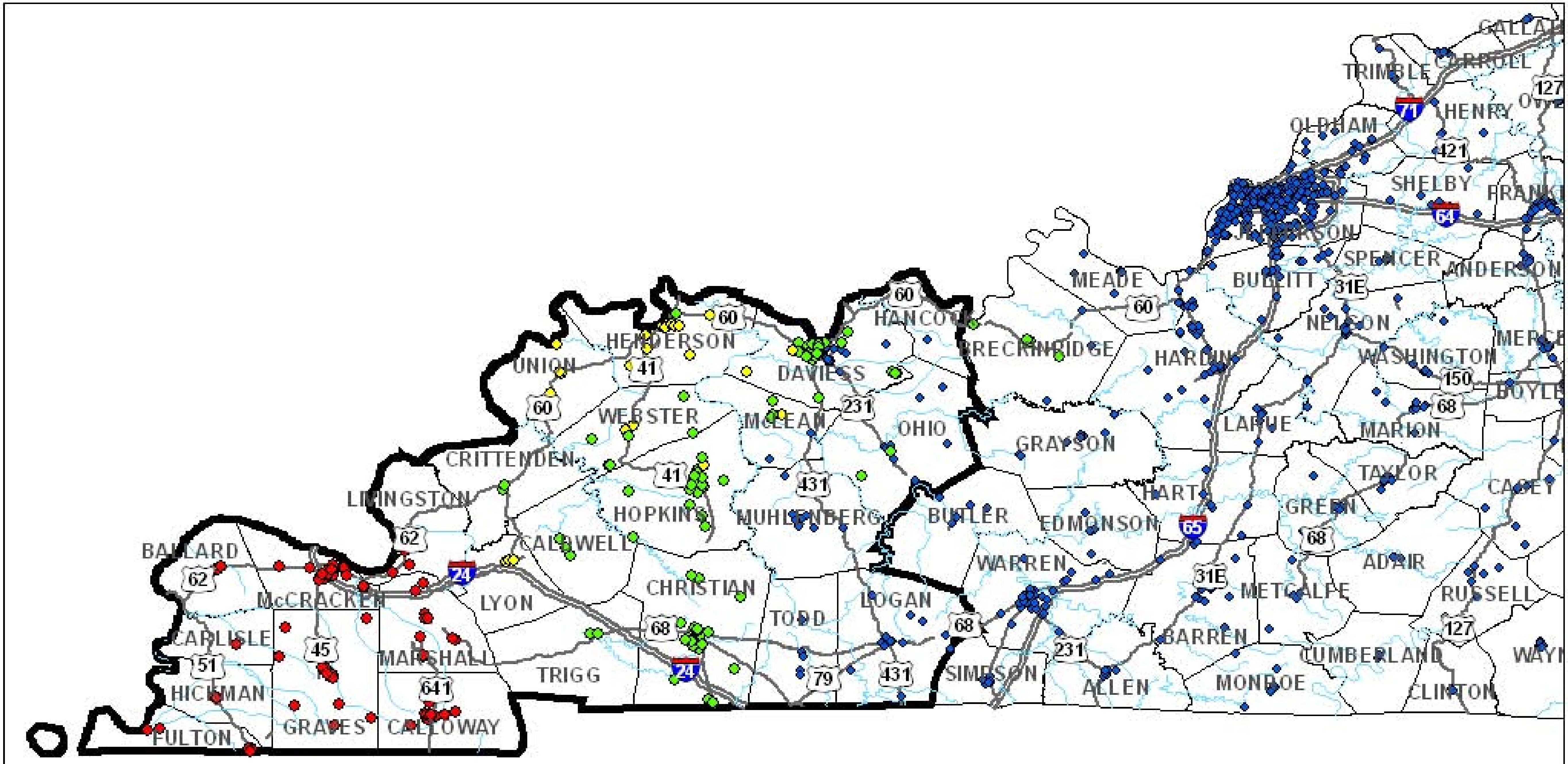
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

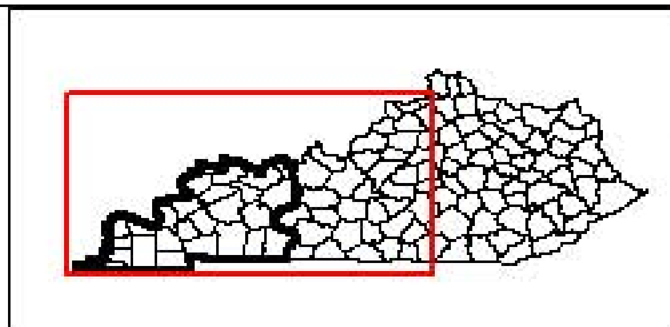
School Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	7	7	4
Caldwell	6	0	0
Calloway	13	13	0
Carlisle	4	4	4
Christian	27	0	0
Crittenden	3	0	0
Daviess	45	0	0
Fulton	9	9	9
Graves	18	18	18
Hancock	4	0	0
Henderson	16	0	0
Hickman	3	3	3
Hopkins	23	0	0
Livingston	5	3	0
Logan	15	0	0
Lyon	5	0	0
McCracken	28	28	28
McLean	6	0	0
Marshall	13	13	13
Muhlenberg	12	0	0
Ohio	12	0	0
Todd	7	0	0
Trigg	5	0	0
Union	7	0	0
Webster	8	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Interstates
US Routes
Rivers

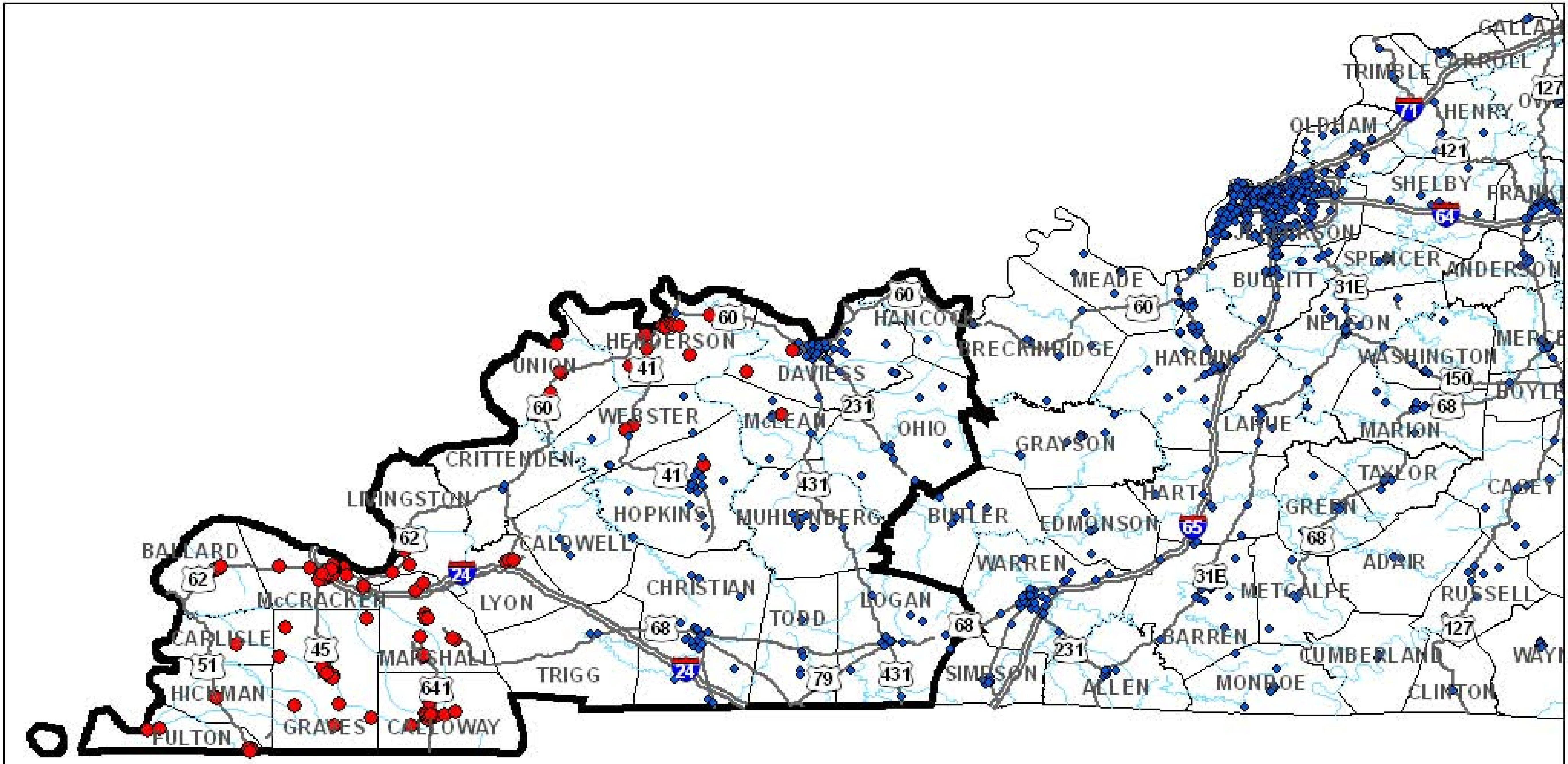
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

School Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

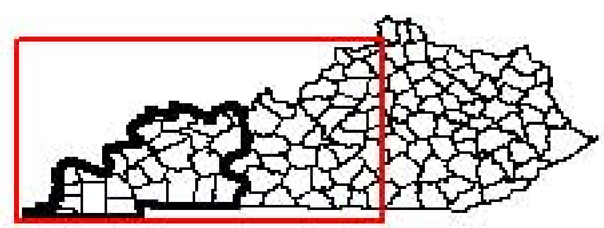
March 2008



State of Kentucky - Critical Counties (25)

County	No. of Funcional Facilities	Total No. of Facilities
Ballard	0	7
Caldwell	6	6
Calloway	0	13
Carlisle	0	4
Christian	27	27
Crittenden	3	3
Daviess	43	45
Fulton	0	9
Graves	0	18
Hancock	4	4
Henderson	1	16
Hickman	0	3
Hopkins	22	23

County	No. of Funcional Facilities	Total No. of Facilities
Livingston	0	5
Logan	15	15
Lyon	0	5
McCracken	0	28
McLean	5	6
Marshall	0	13
Muhlenberg	12	12
Ohio	12	12
Todd	7	7
Trigg	5	5
Union	0	7
Webster	6	8



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

School Functionality

Day 1

- Not Functional
- Functional

US Routes
Interstates
Critical Counties
Rivers

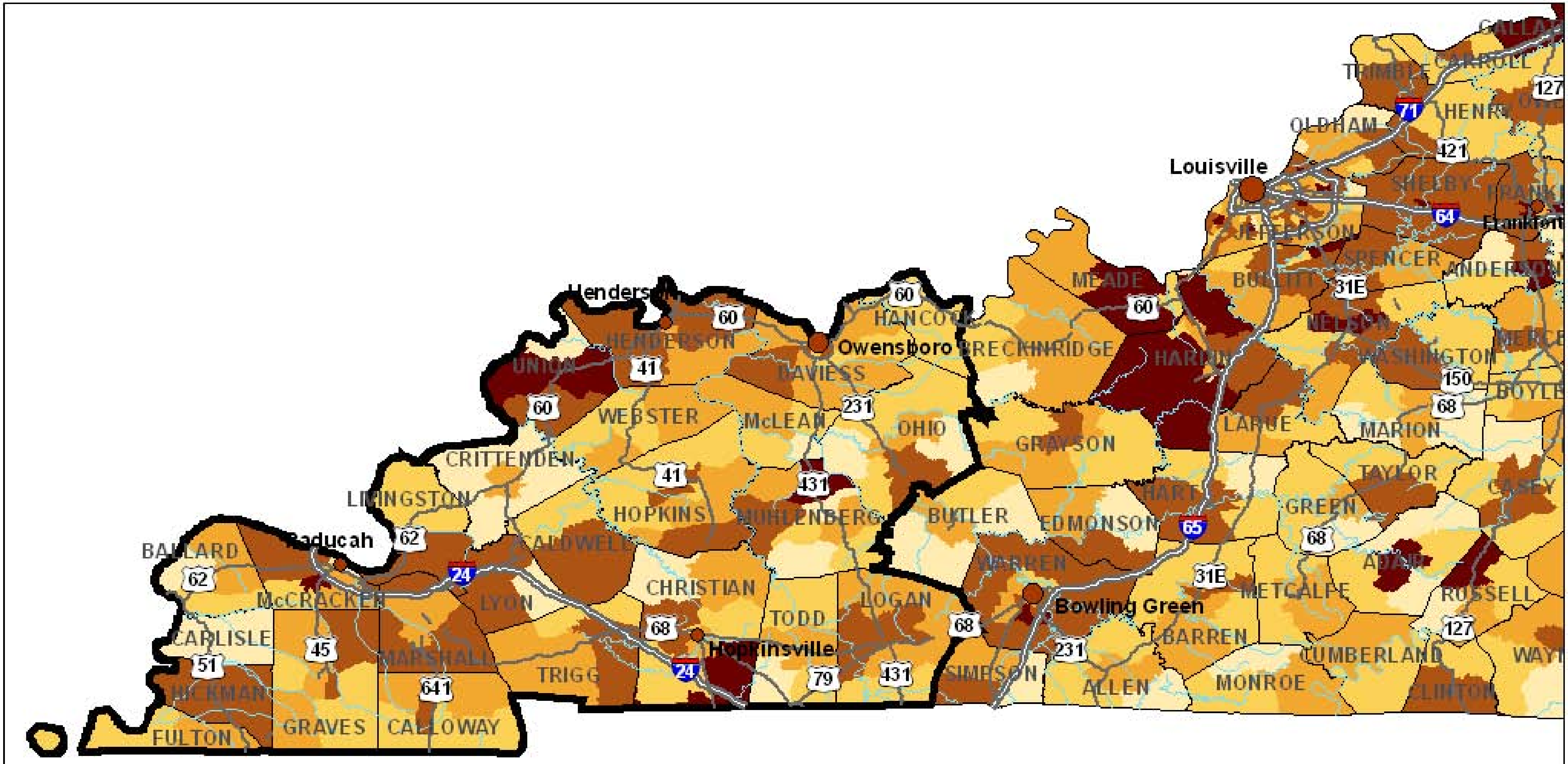
0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

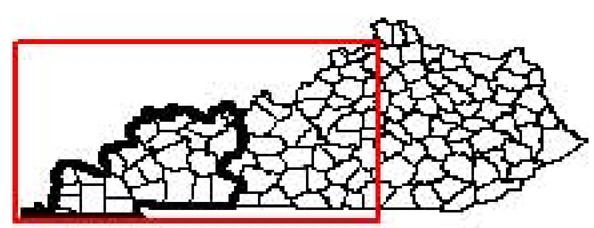
Total Population (2000) - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Population	County	Population	County	Population
Ballard	8,286	Hancock	8,392	Marshall	30,125
Caldwell	13,060	Henderson	44,829	Muhlenberg	31,839
Calloway	34,177	Hickman	5,262	Ohio	22,916
Carlisle	5,351	Hopkins	46,519	Todd	11,971
Christian	72,265	Livingston	9,804	Trigg	12,597
Crittenden	9,384	Logan	26,573	Union	15,637
Daviess	91,545	Lyon	8,080	Webster	14,120
Fulton	7,752	McCracken	65,514		
Graves	37,028	McLean	9,938		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Total Population (HAZUS - 2000)

- 0 - 2,000
- 2,001 - 3,500
- 3,501 - 5,000
- 5,001 - 7,500
- 7,501 - 15,400

Major Cities

- 25,000 - 40,000
- 40,001 - 60,000
- 60,001 - 271,000

- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

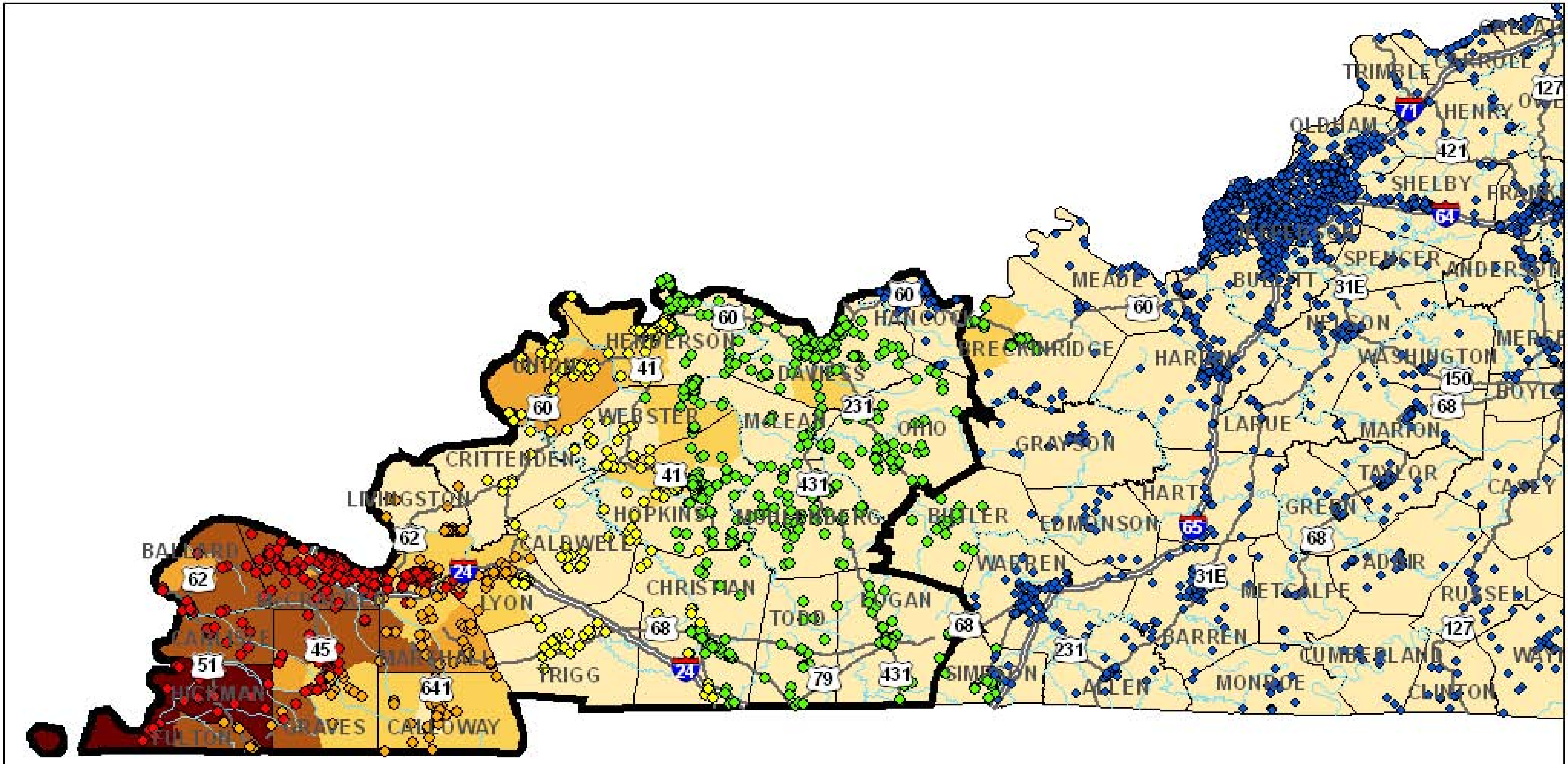
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

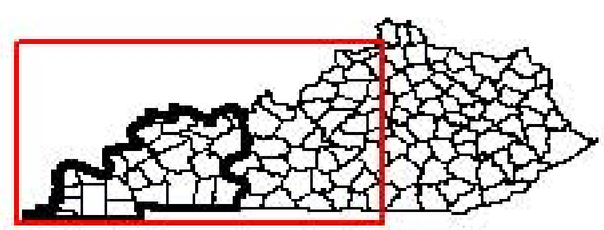
Waste Water System Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Kentucky - Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Ballard	22	22	12
Caldwell	16	0	0
Calloway	40	40	0
Carlisle	16	16	0
Christian	83	0	0
Crittenden	11	2	0
Daviess	162	0	0
Fulton	15	15	0
Graves	57	57	0
Hancock	82	0	0
Henderson	165	0	0
Hickman	24	24	0
Hopkins	99	0	0
Livingston	51	51	0
Logan	45	0	0
Lyon	33	24	0
McCracken	147	147	69
McLean	19	0	0
Marshall	125	125	0
Muhlenberg	89	0	0
Ohio	102	0	0
Todd	20	0	0
Trigg	28	0	0
Union	51	0	0
Webster	59	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Waste Water Facility Damage At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Waste Water Distribution Lines No. of Leaks

- 0 - 10
- 11 - 50
- 51 - 100
- 101 - 500
- 501 - 800

US Routes
Interstates
Critical Counties
Rivers

0 5 10 20 30
Miles

Mid-America Earthquake Center

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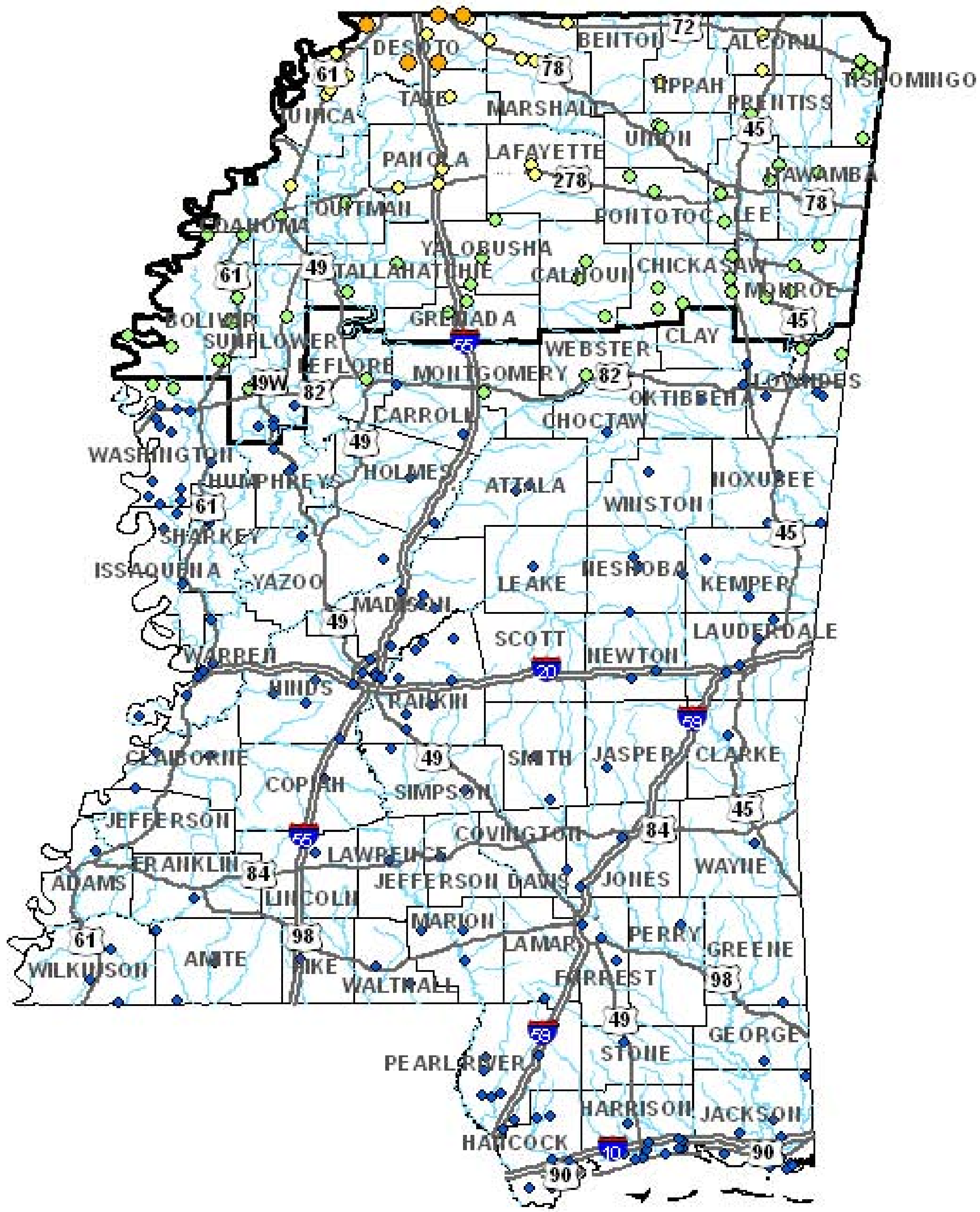
Airport Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	2	0	0
Benton	0	0	0
Bolivar	11	0	0
Calhoun	3	0	0
Chickasaw	6	0	0
Coahoma	2	0	0
Desoto	7	5	0
Grenada	2	0	0
Itawamba	2	0	0
Lafayette	2	0	0
Lee	3	0	0
Marshall	5	0	0
Monroe	4	0	0
Panola	3	0	0
Pontotoc	2	0	0
Prentiss	1	0	0
Quitman	1	0	0
Sunflower	6	0	0
Tallahatchie	3	0	0
Tate	1	0	0
Tippah	1	0	0
Tishomingo	4	0	0
Tunica	4	0	0
Union	2	0	0
Yalobusha	3	0	0

Legend

Airport Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Interstates

US Routes

Rivers

Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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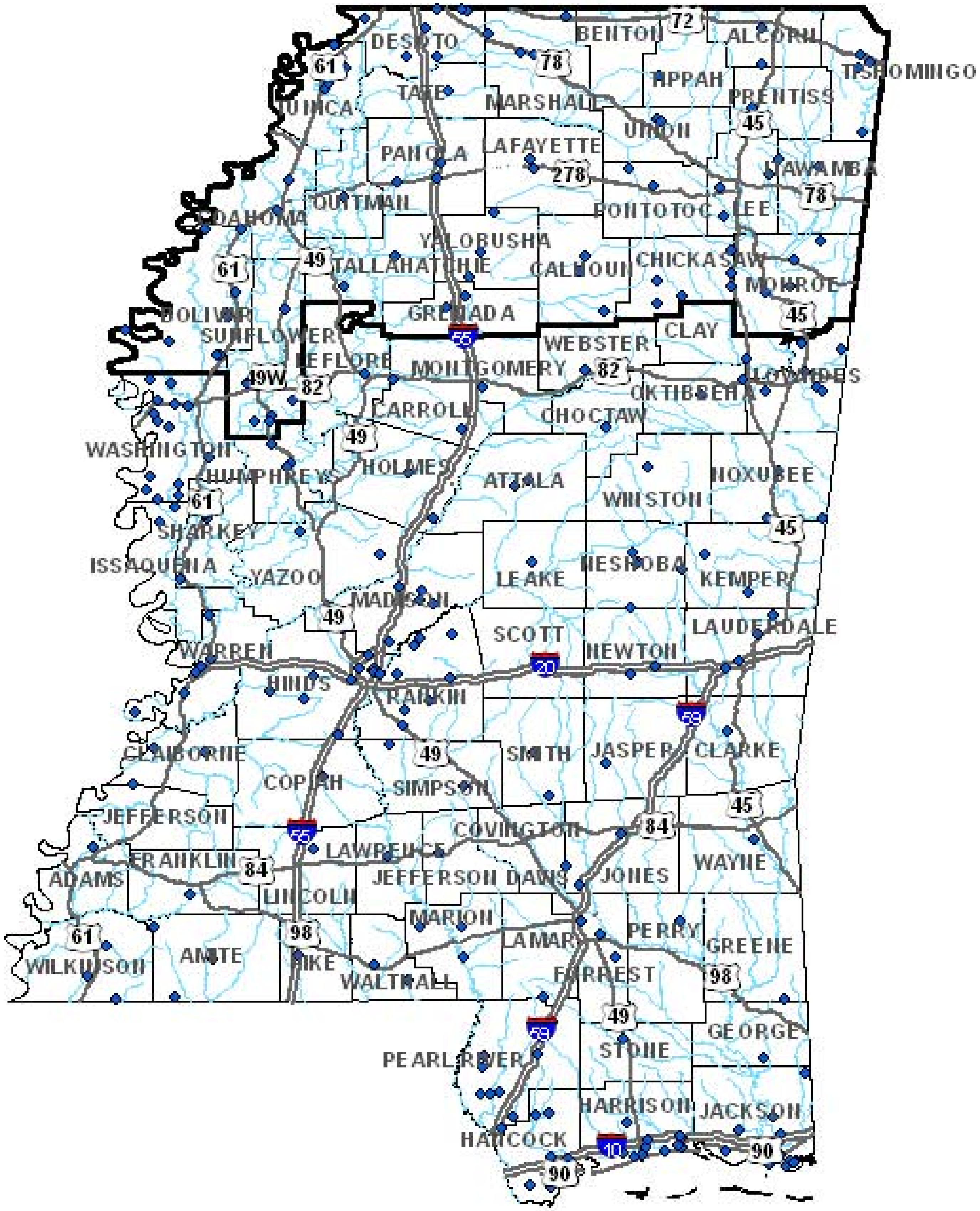
Airport Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	2	2
Benton	0	0
Bolivar	11	11
Calhoun	3	3
Chickasaw	6	6
Coahoma	2	2
Desoto	7	7
Grenada	2	2
Itawamba	2	2
Lafayette	2	2
Lee	3	3
Marshall	5	5
Monroe	4	4
Panola	3	3
Pontotoc	2	2
Prentiss	1	1
Quitman	1	1
Sunflower	6	6
Tallahatchie	3	3
Tate	1	1
Tippah	1	1
Tishomingo	4	4
Tunica	4	4
Union	2	2
Yalobusha	3	3

Legend

Airport Functionality

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

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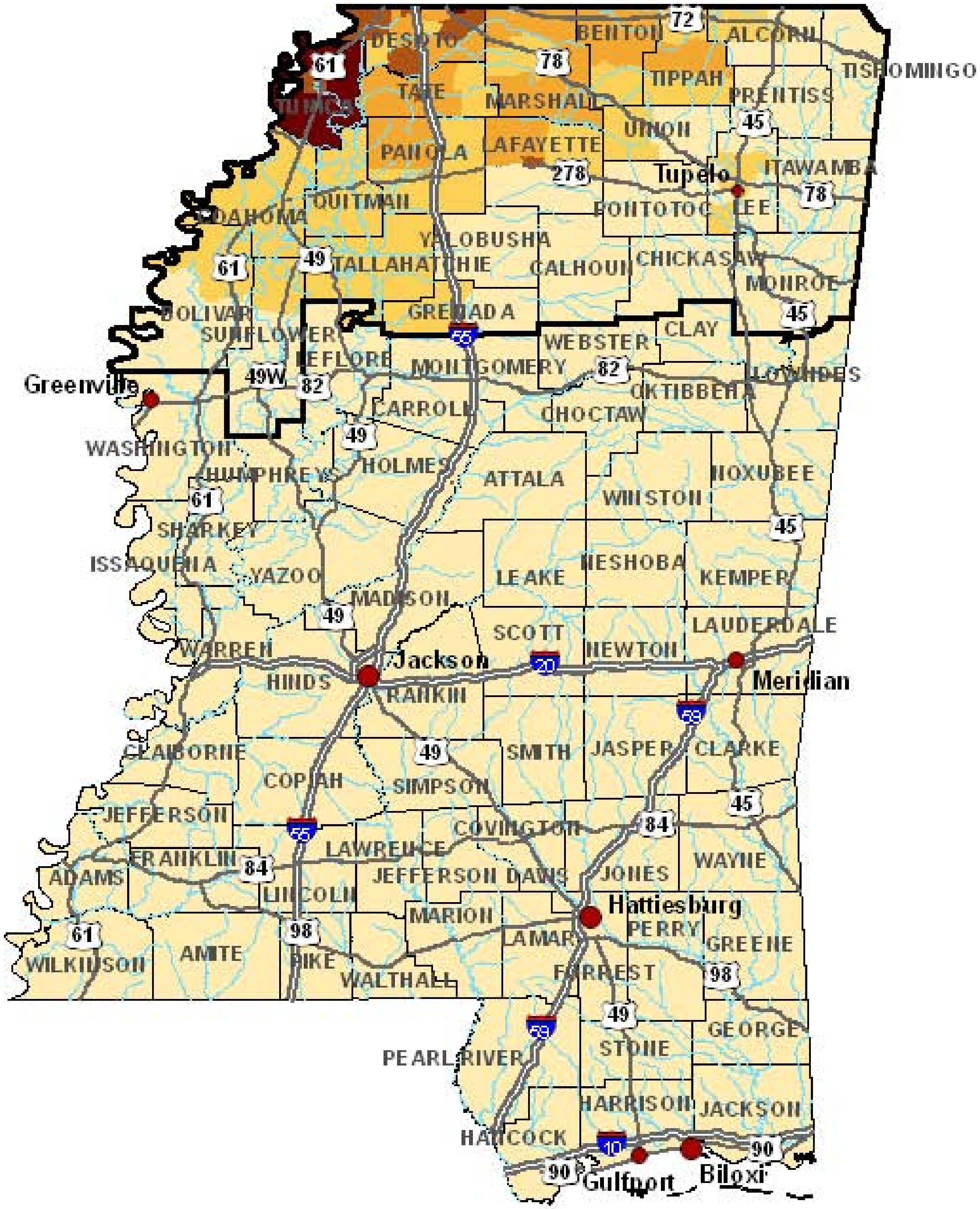
Worst Case Casualties (2PM) - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Alcorn	19	0	19
Benton	32	1	34
Bolivar	24	1	25
Calhoun	2	0	2
Chickasaw	4	0	4
Coahoma	76	3	79
Desoto	2,130	136	2,266
Grenada	19	0	19
Itawamba	3	0	3
Lafayette	234	10	245
Lee	25	0	25
Marshall	190	8	198
Monroe	7	0	7
Panola	134	5	139
Pontotoc	4	0	4
Prentiss	5	0	5
Quitman	18	1	19
Sunflower	22	1	23
Tallahatchie	25	1	26
Tate	261	15	276
Tippah	83	4	87
Tishomingo	4	0	4
Tunica	362	21	383
Union	22	1	23
Yalobusha	2	0	2

Legend

Worst Case Casualties (2 PM)

- 0 - 5
- 6 - 50
- 51 - 150
- 151 - 350
- 351 - 785

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000

- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
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Theresa Jefferson, Principal Investigator

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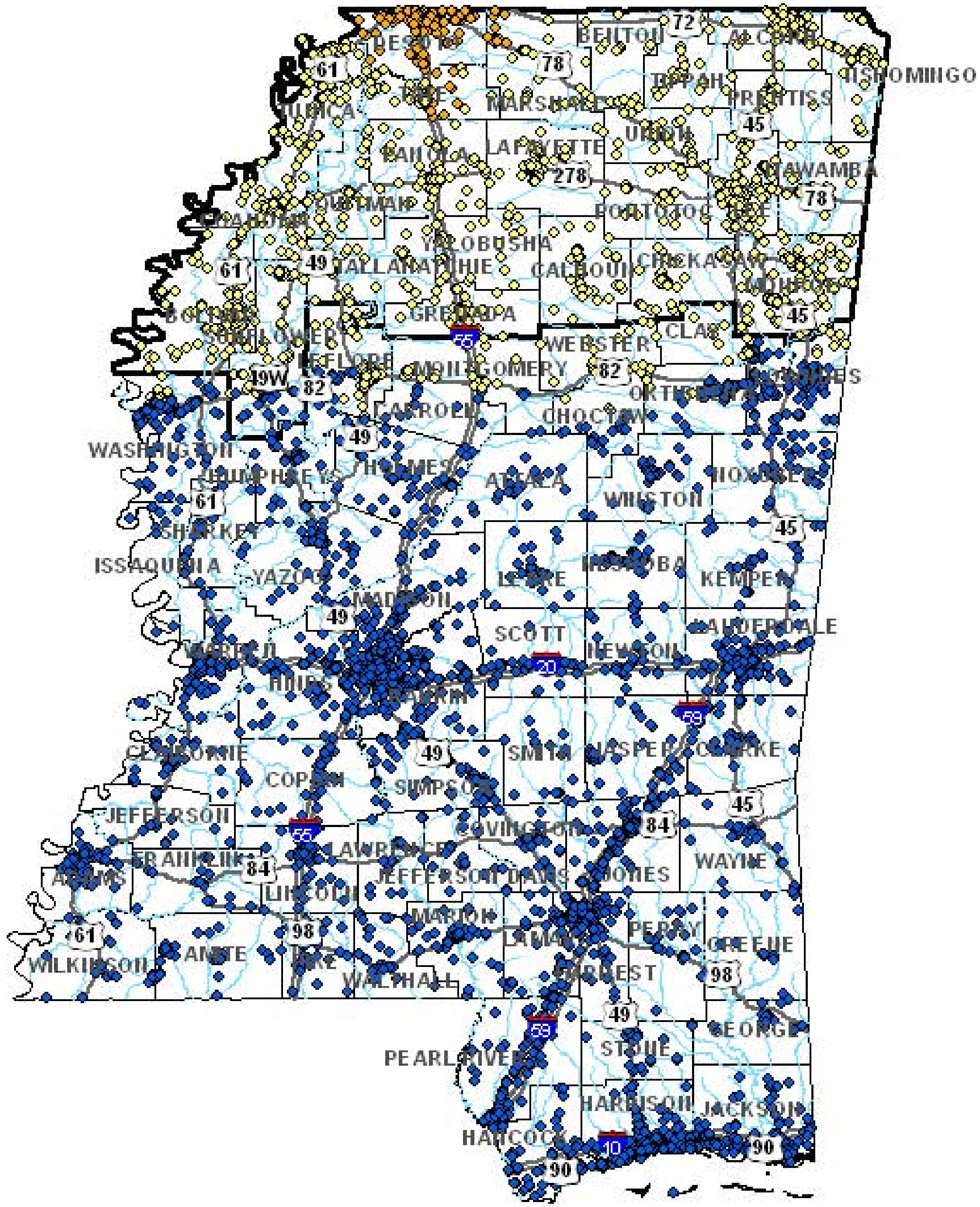
Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	172	0	0
Benton	23	0	0
Bolivar	207	0	0
Calhoun	66	0	0
Chickasaw	78	0	0
Coahoma	121	0	0
Desoto	250	250	0
Grenada	74	0	0
Itawamba	55	0	0
Lafayette	99	0	0
Lee	219	0	0
Marshall	114	27	0
Monroe	186	0	0
Panola	112	0	0
Pontotoc	70	0	0
Prentiss	45	0	0
Quitman	60	0	0
Sunflower	128	0	0
Tallahatchie	60	0	0
Tate	69	13	0
Tippah	55	0	0
Tishomingo	65	0	0
Tunica	117	0	0
Union	73	0	0
Yalobusha	35	0	0

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center

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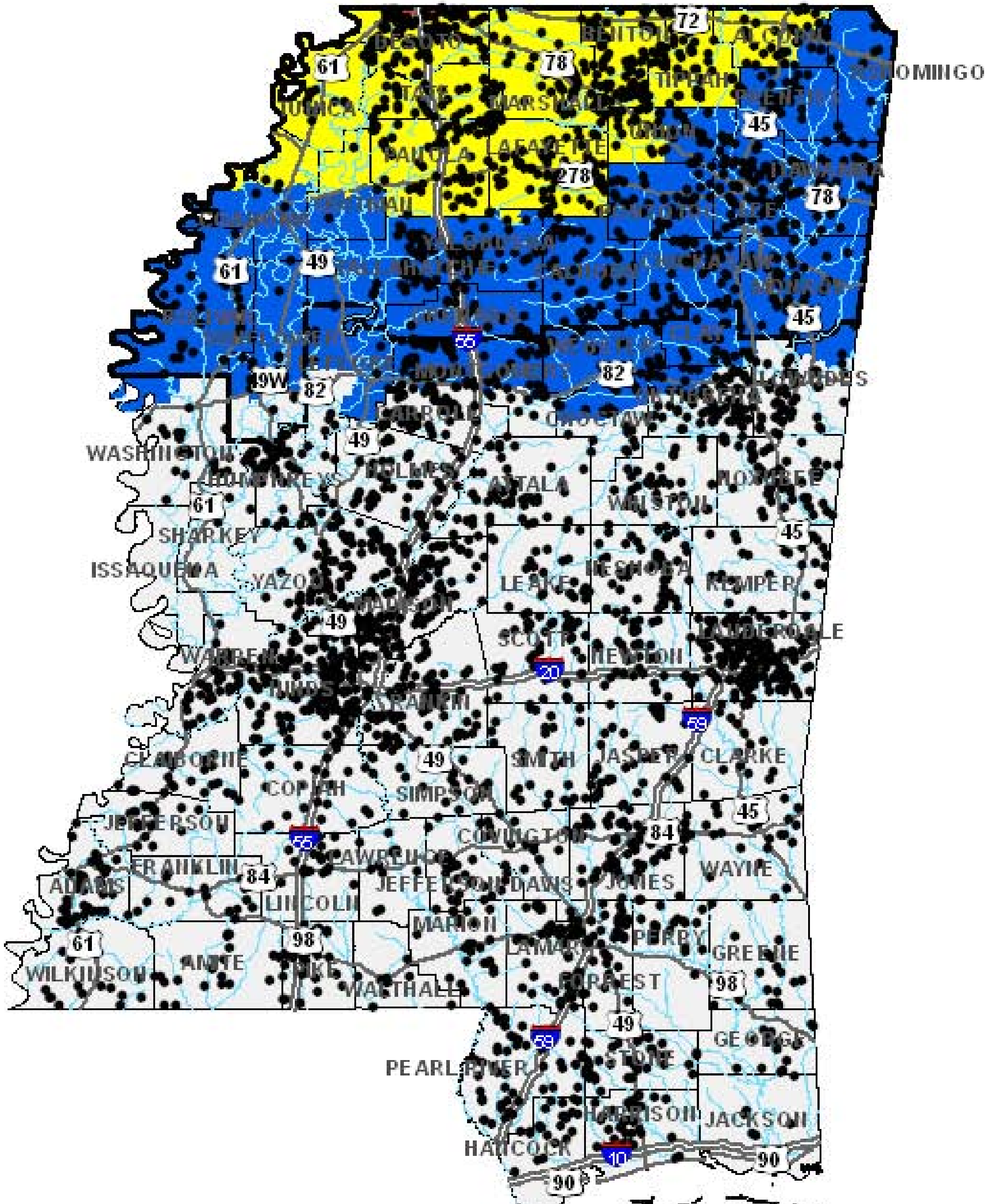
Theresa Jefferson, Principal Investigator

Dams - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Facilities
Alcorn	38
Benton	80
Bolivar	26
Calhoun	48
Chickasaw	40
Coahoma	5
Desoto	119
Grenada	22
Itawamba	43
Lafayette	79
Lee	70
Marshall	52
Monroe	41
Panola	64
Pontotoc	37
Prentiss	29
Quitman	3
Sunflower	16
Tallahatchie	46
Tate	46
Tippah	56
Tishomingo	10
Tunica	13
Union	49
Yalobusha	48

Legend

- Dams

Modified Mercalli Intensity

- < VI
- VI
- VII
- VIII
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center

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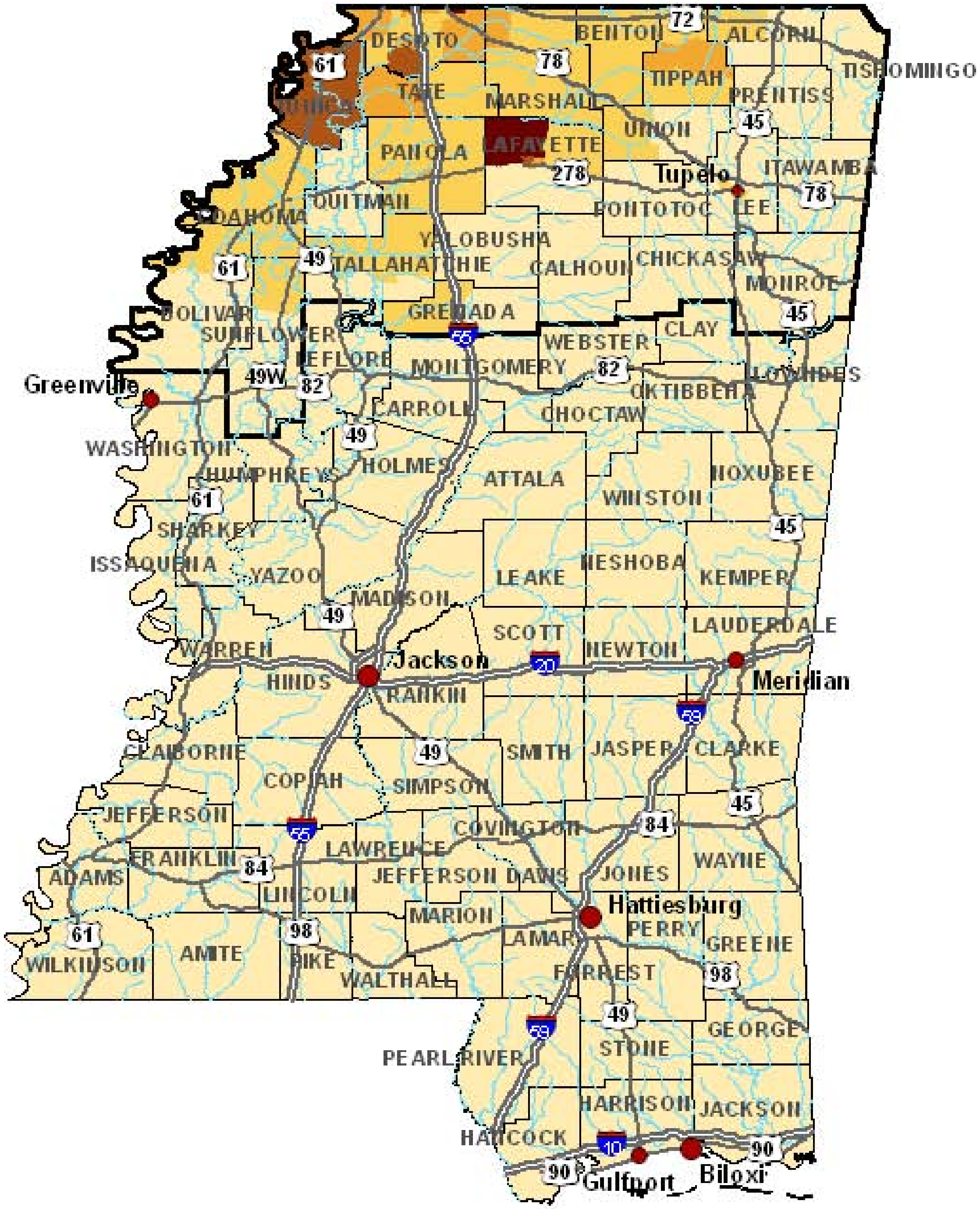
Total Debris - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Thousands of Tons Brick/ Wood	Concrete/ Steel	Total Debris
Alcorn	14.62	8.88	23.50
Benton	12.68	11.47	24.15
Bolivar	10.42	9.63	20.04
Calhoun	3.06	1.61	4.67
Chickasaw	4.19	2.25	6.44
Coahoma	13.66	32.85	46.51
Desoto	360.68	533.81	894.49
Grenada	8.97	9.81	18.78
Itawamba	4.36	1.68	6.03
Lafayette	102.37	278.90	381.27
Lee	22.78	15.97	38.75
Marshall	64.19	64.34	128.53
Monroe	6.56	2.64	9.19
Panola	49.73	60.55	110.28
Pontotoc	4.94	2.29	7.24
Prentiss	5.23	2.17	7.40
Quitman	5.24	6.62	11.86
Sunflower	5.57	7.70	13.27
Tallahatchie	11.03	15.15	26.18
Tate	72.97	90.66	163.63
Tippah	39.79	50.79	90.58
Tishomingo	4.34	1.84	6.18
Tunica	58.03	64.04	122.07
Union	17.17	12.04	29.21
Yalobusha	2.40	0.77	3.17

Legend

Total Debris

Thousands of Tons

- 0 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 270
- US Routes
- Interstates
- Rivers
- Critical Counties

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000

0 10 20 40 60
Miles

Mid-America Earthquake Center

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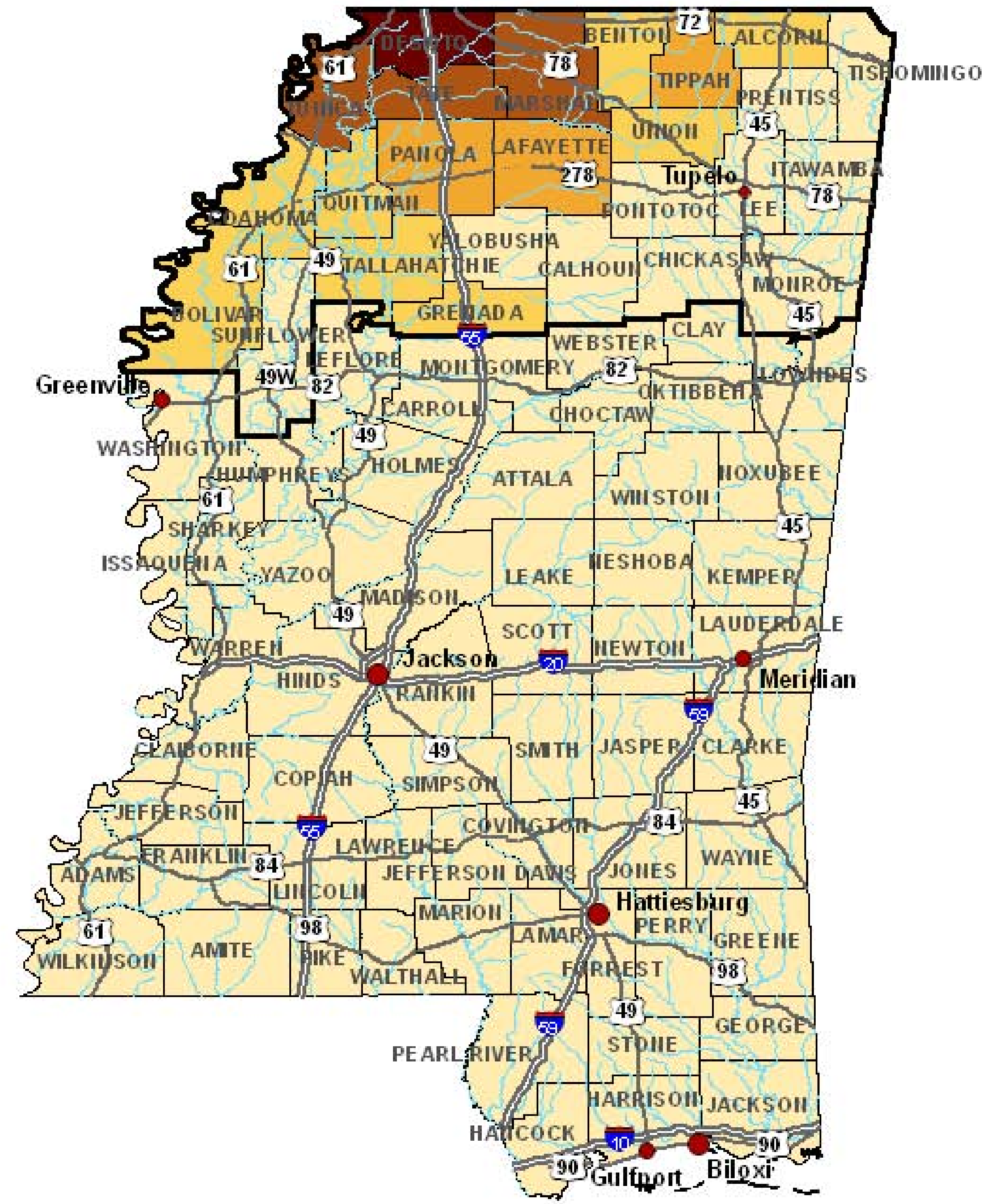
Displaced Population - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Displaced Residences	Estimate of Displaced Population
Alcorn	42	101
Benton	79	211
Bolivar	42	125
Calhoun	0	1
Chickasaw	0	1
Coahoma	71	205
Desoto	4,139	11,438
Grenada	35	93
Itawamba	0	0
Lafayette	313	844
Lee	4	9
Marshall	458	1,318
Monroe	1	2
Panola	304	851
Pontotoc	0	1
Prentiss	1	2
Quitman	46	130
Sunflower	14	50
Tallahatchie	98	278
Tate	737	2,114
Tippah	140	359
Tishomingo	0	1
Tunica	881	2,494
Union	78	203
Yalobusha	0	1

Legend

Displaced Population

- 0 - 50
- 51 - 300
- 301 - 1,000
- 1,001 - 2,500
- 2,501 - 11,500
- US Routes
- Interstates
- Critical Counties
- Rivers

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000

0 10 20 40 60
Miles

Mid-America Earthquake Center

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Theresa Jefferson, Principal Investigator

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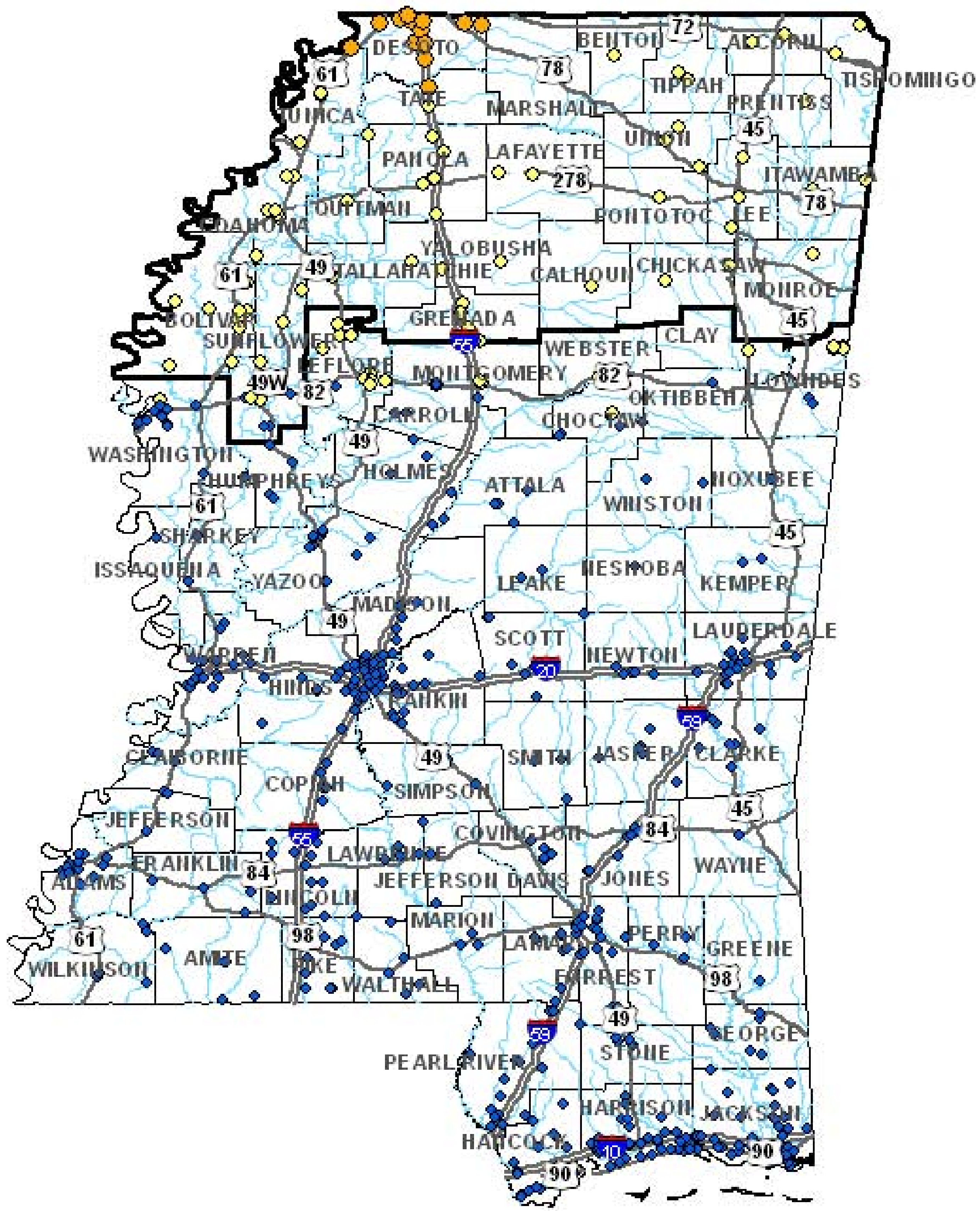
Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	2	0	0
Benton	2	0	0
Bolivar	13	0	0
Calhoun	1	0	0
Chickasaw	2	0	0
Coahoma	24	0	0
Desoto	23	23	0
Grenada	5	0	0
Itawamba	3	0	0
Lafayette	2	0	0
Lee	3	0	0
Marshall	1	0	0
Monroe	2	0	0
Panola	8	0	0
Pontotoc	1	0	0
Prentiss	1	0	0
Quitman	1	0	0
Sunflower	11	0	0
Tallahatchie	2	0	0
Tate	2	1	0
Tippah	2	0	0
Tishomingo	2	0	0
Tunica	3	0	0
Union	10	0	0
Yalobusha	2	0	0

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Interstates
US Routes
Critical Counties
Rivers

0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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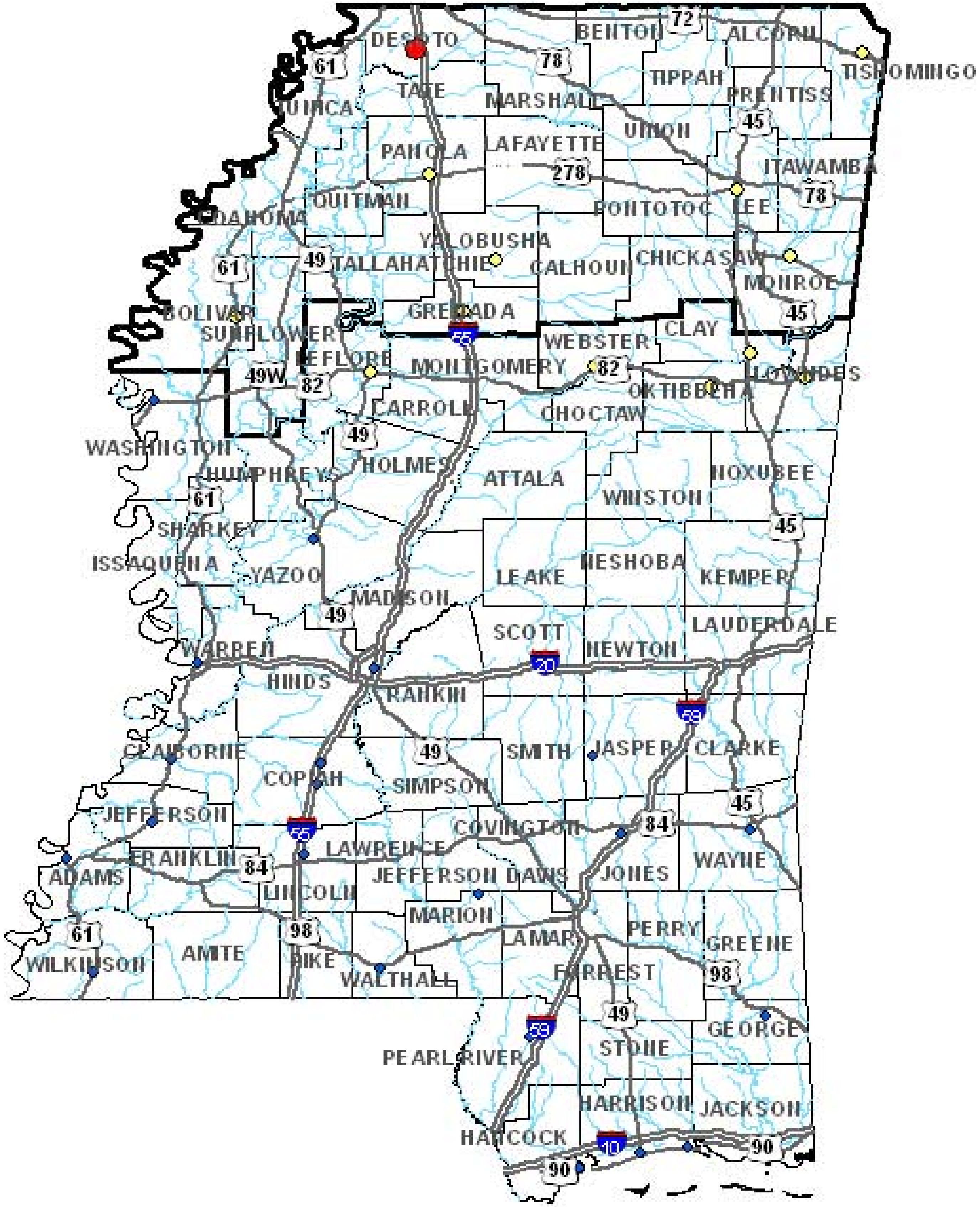
Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	0	0	0
Benton	0	0	0
Bolivar	1	0	0
Calhoun	0	0	0
Chickasaw	0	0	0
Coahoma	0	0	0
Desoto	1	1	0
Grenada	1	0	0
Itawamba	1	0	0
Lafayette	0	0	0
Lee	1	0	0
Marshall	0	0	0
Monroe	1	0	0
Panola	1	0	0
Pontotoc	0	0	0
Prentiss	0	0	0
Quitman	0	0	0
Sunflower	0	0	0
Tallahatchie	1	0	0
Tate	0	0	0
Tippah	0	0	0
Tishomingo	1	0	0
Tunica	0	0	0
Union	0	0	0
Yalobusha	1	0	0

Legend

Emergency Operation Centers

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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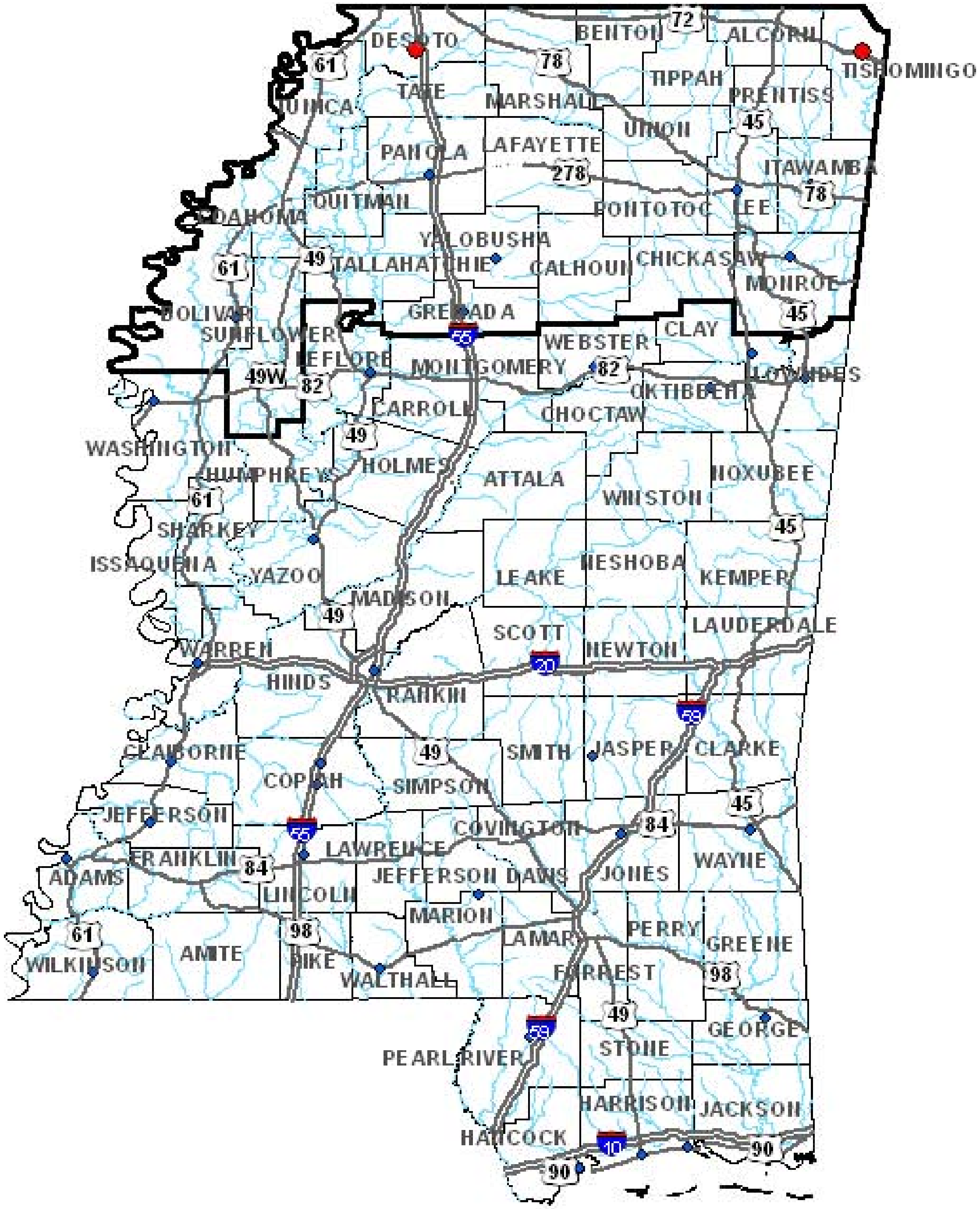
Emergency Oper. Center Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	0	0
Benton	0	0
Bolivar	1	1
Calhoun	0	0
Chickasaw	0	0
Coahoma	0	0
Desoto	0	1
Grenada	1	1
Itawamba	1	1
Lafayette	0	0
Lee	1	1
Marshall	0	0
Monroe	1	1
Panola	1	1
Pontotoc	0	0
Prentiss	0	0
Quitman	0	0
Sunflower	0	0
Tallahatchie	1	1
Tate	0	0
Tippah	0	0
Tishomingo	0	1
Tunica	0	0
Union	0	0
Yalobusha	1	1

Legend

Emergency Operation Centers

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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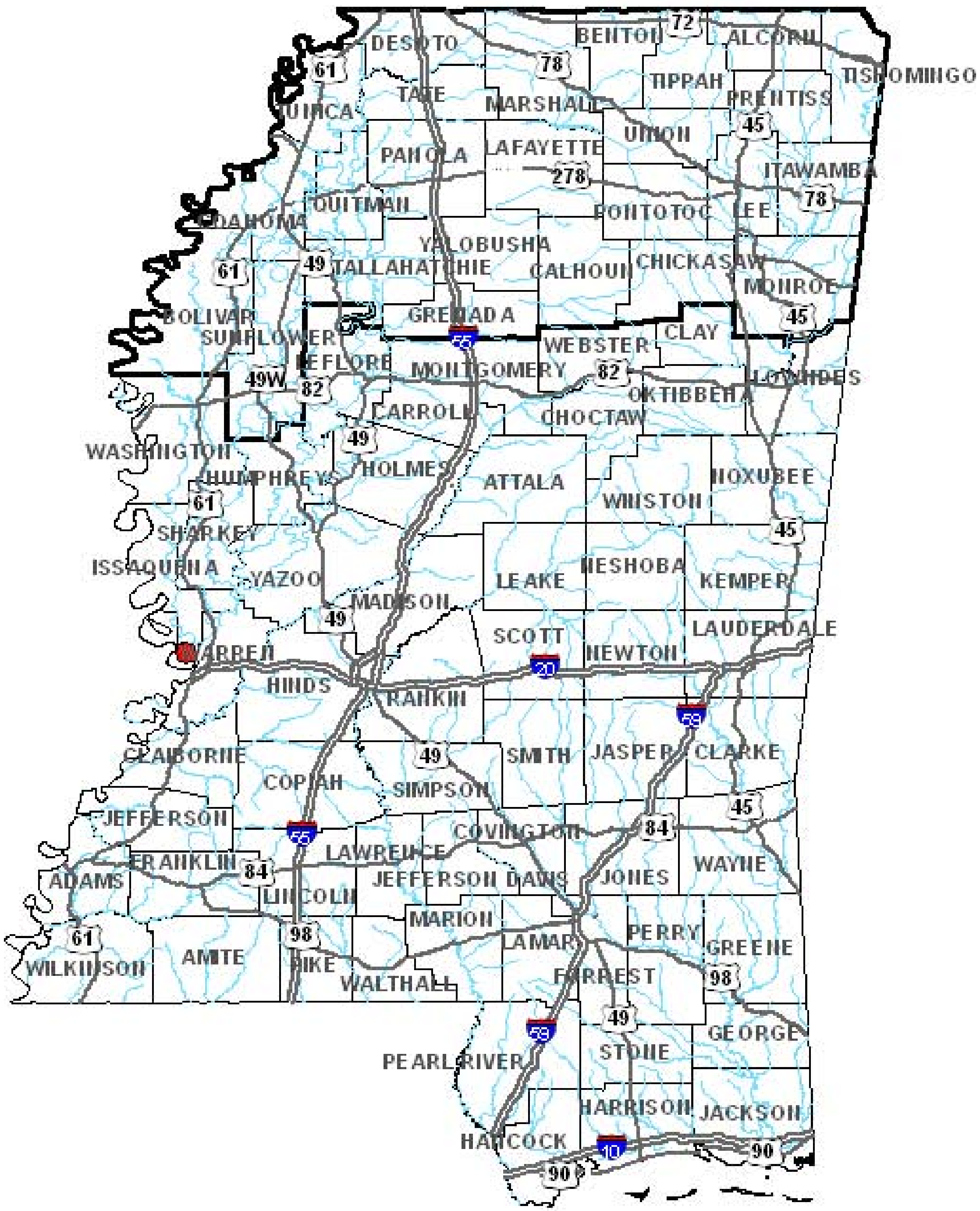
Ferry Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	0	0	0
Benton	0	0	0
Bolivar	0	0	0
Calhoun	0	0	0
Chickasaw	0	0	0
Coahoma	0	0	0
Desoto	0	0	0
Grenada	0	0	0
Itawamba	0	0	0
Lafayette	0	0	0
Lee	0	0	0
Marshall	0	0	0
Monroe	0	0	0
Panola	0	0	0
Pontotoc	0	0	0
Prentiss	0	0	0
Quitman	0	0	0
Sunflower	0	0	0
Tallahatchie	0	0	0
Tate	0	0	0
Tippah	0	0	0
Tishomingo	0	0	0
Tunica	0	0	0
Union	0	0	0
Yalobusha	0	0	0

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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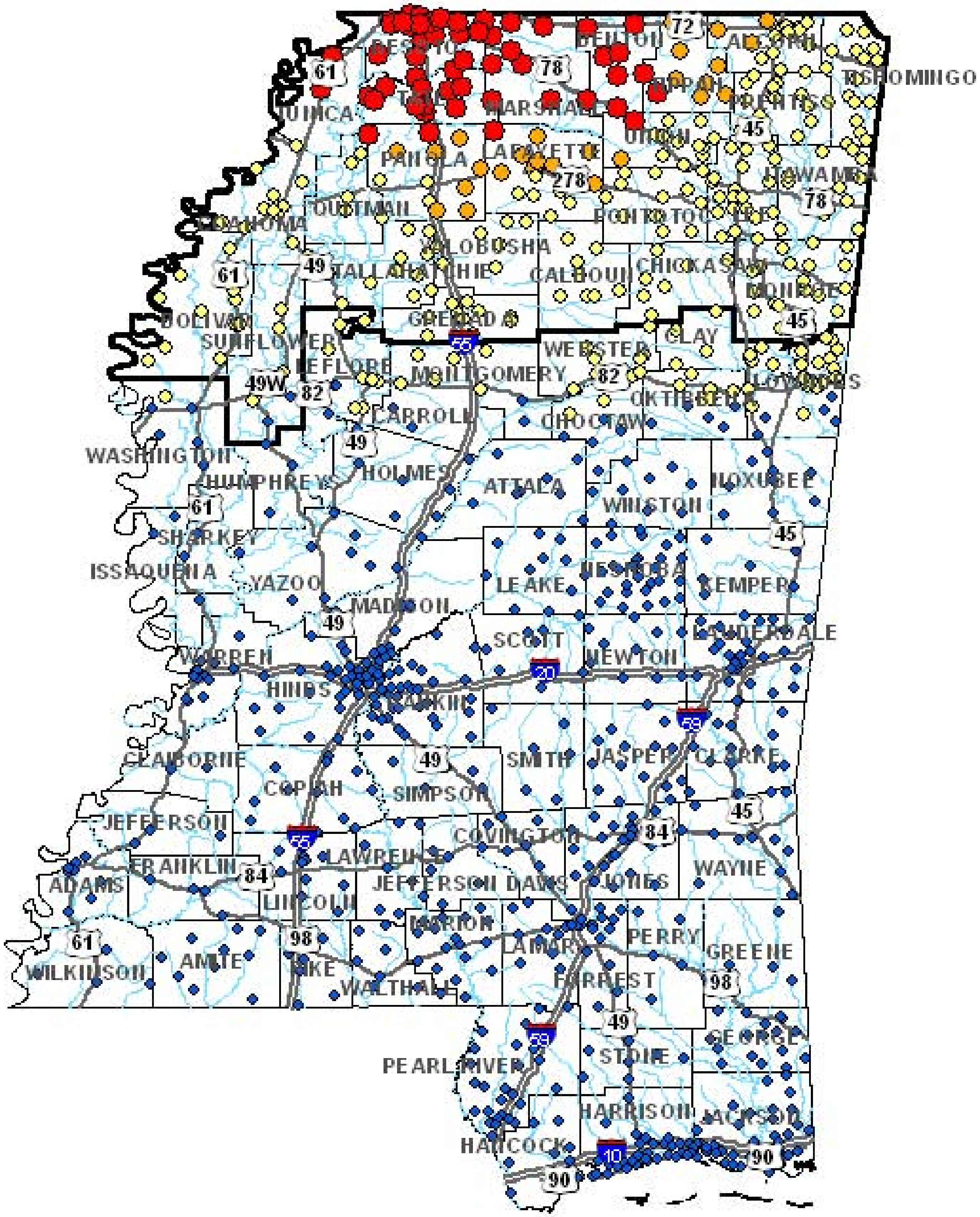
Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	15	3	0
Benton	6	6	0
Bolivar	14	0	0
Calhoun	8	0	0
Chickasaw	7	0	0
Coahoma	11	0	0
Desoto	19	19	3
Grenada	10	0	0
Itawamba	12	0	0
Lafayette	16	10	0
Lee	22	0	0
Marshall	9	9	0
Monroe	22	0	0
Panola	12	9	0
Pontotoc	12	0	0
Prentiss	14	0	0
Quitman	5	0	0
Sunflower	7	0	0
Tallahatchie	14	0	0
Tate	12	12	0
Tippah	9	9	0
Tishomingo	16	0	0
Tunica	2	2	0
Union	13	2	0
Yalobusha	7	0	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Interstates
- US Routes
- Rivers
- Critical Counties

Mid-America Earthquake Center

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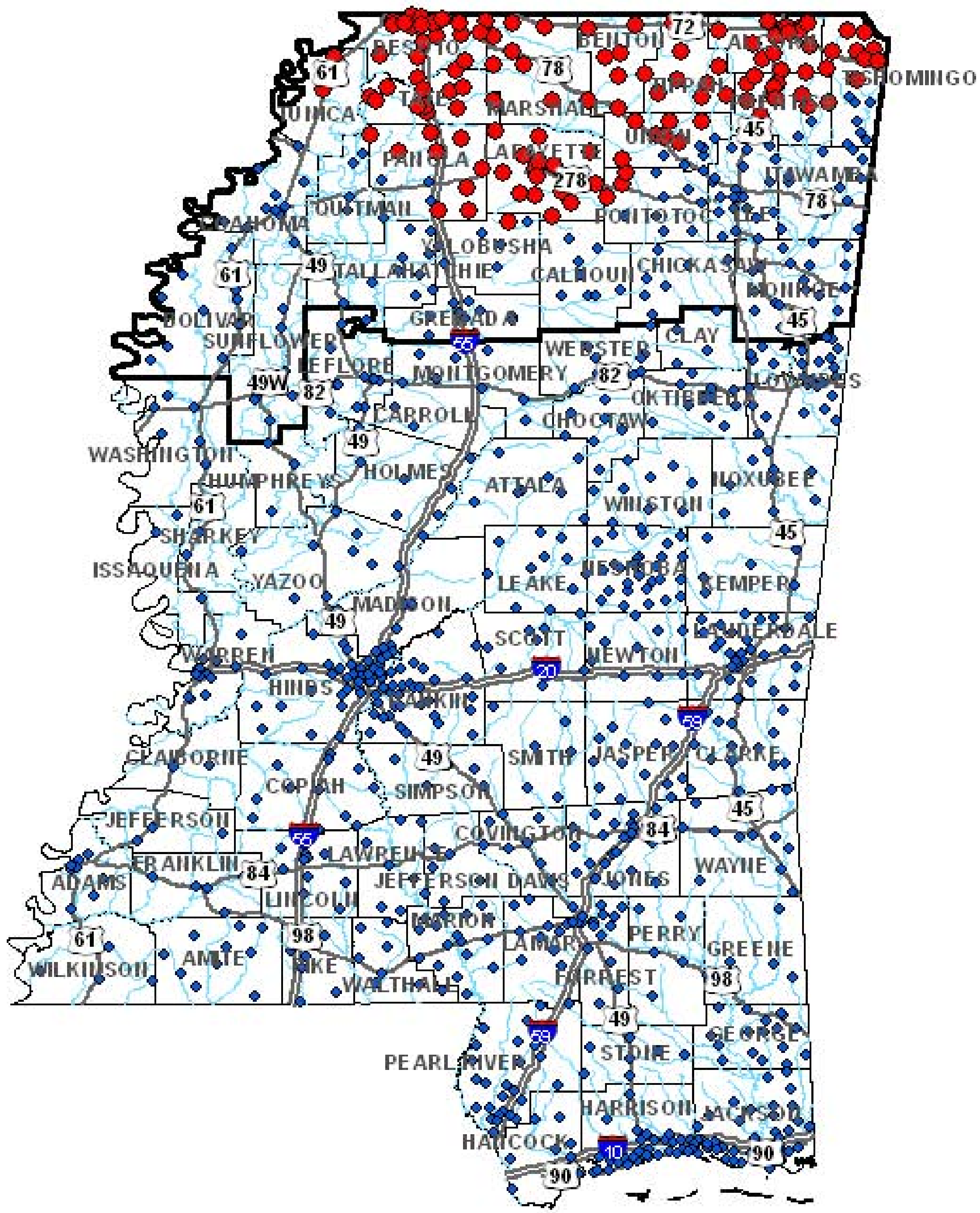
Fire Station Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	0	15
Benton	0	6
Bolivar	14	14
Calhoun	8	8
Chickasaw	7	7
Coahoma	11	11
Desoto	0	19
Grenada	10	10
Itawamba	12	12
Lafayette	0	16
Lee	22	22
Marshall	0	9
Monroe	22	22
Panola	3	12
Pontotoc	9	12
Prentiss	3	14
Quitman	5	5
Sunflower	7	7
Tallahatchie	14	14
Tate	0	12
Tippah	0	9
Tishomingo	7	16
Tunica	0	2
Union	6	13
Yalobusha	6	7

Legend

Fire Station Functionality

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Critical Counties
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

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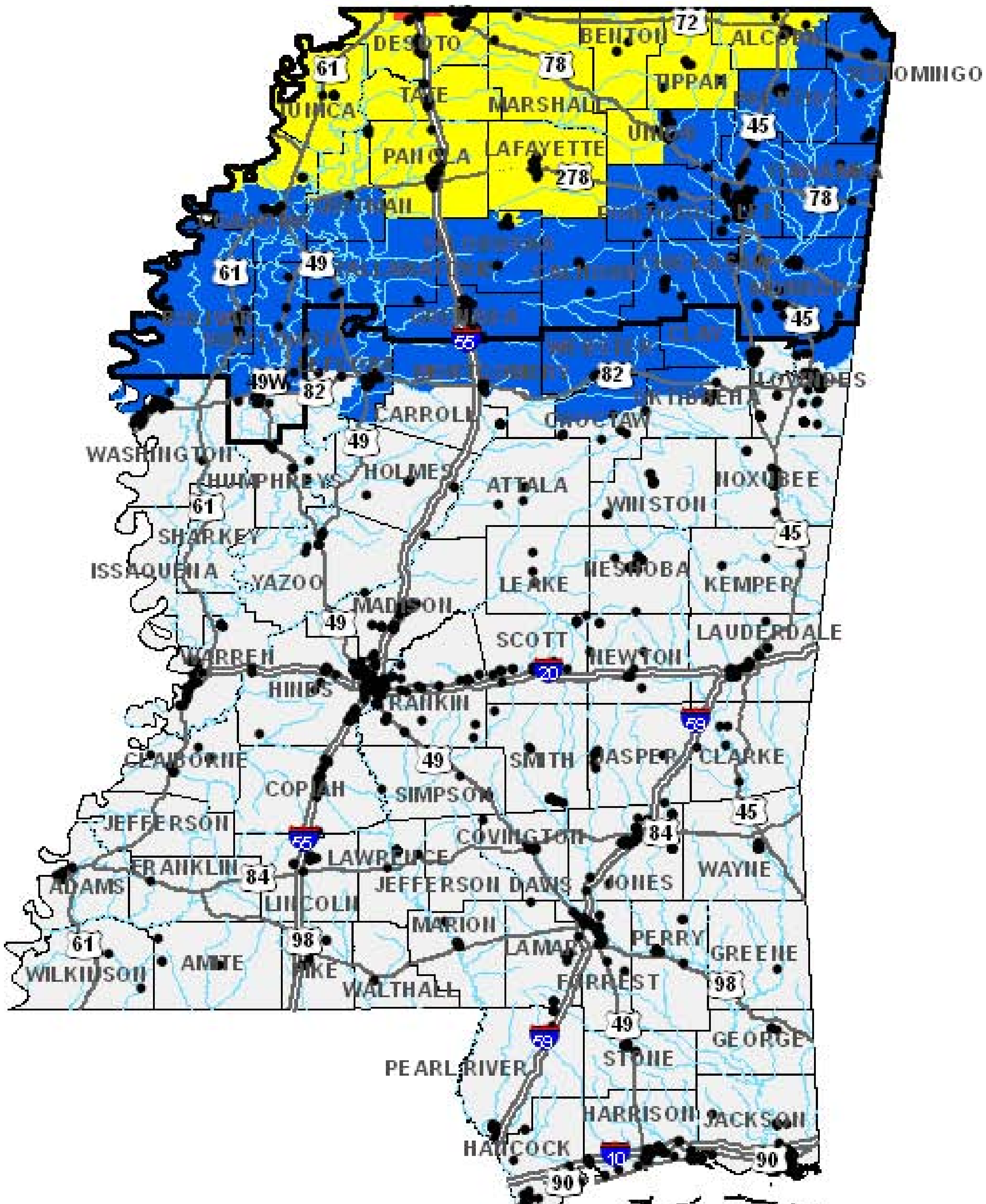
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Facilities
Alcorn	14
Benton	3
Bolivar	17
Calhoun	4
Chickasaw	12
Coahoma	19
Desoto	91
Grenada	51
Itawamba	17
Lafayette	13
Lee	88
Marshall	14
Monroe	54
Panola	34
Pontotoc	12
Prentiss	16
Quitman	4
Sunflower	18
Tallahatchie	3
Tate	15
Tippah	10
Tishomingo	17
Tunica	10
Union	31
Yalobusha	7

Legend

- Hazardous Materials Facilities

Modified Mercalli Intensity

- < VI
- VI
- VII
- VIII
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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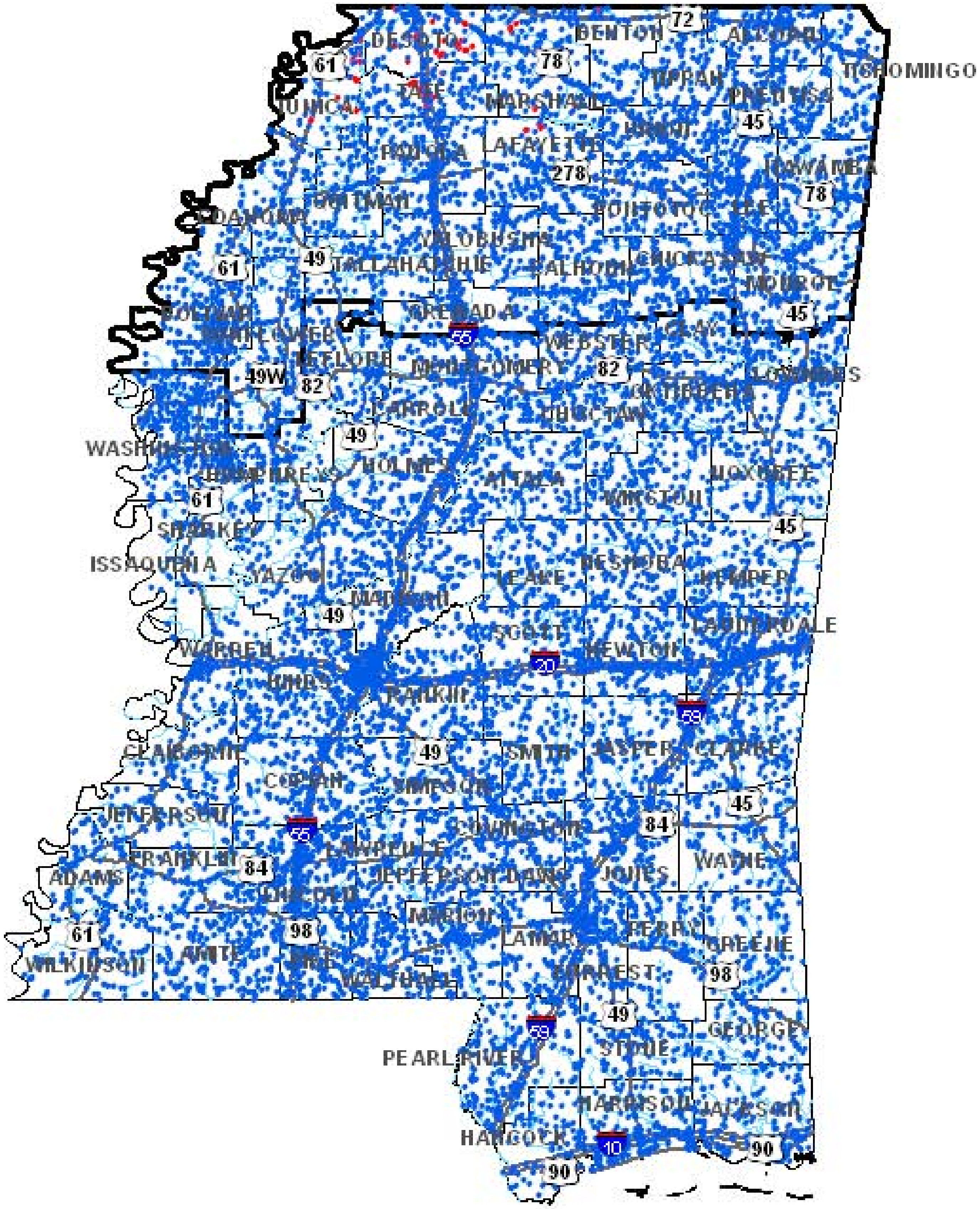
Highway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	234	234
Benton	119	120
Bolivar	286	286
Calhoun	224	224
Chickasaw	231	231
Coahoma	111	112
Desoto	179	204
Grenada	171	171
Itawamba	240	240
Lafayette	258	263
Lee	377	377
Marshall	251	256
Monroe	289	289
Panola	251	251
Pontotoc	164	164
Prentiss	206	206
Quitman	117	117
Sunflower	189	189
Tallahatchie	155	155
Tate	138	157
Tippah	175	175
Tishomingo	138	138
Tunica	54	63
Union	242	242
Yalobusha	179	179

Legend

Highway Bridge Functionality

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60 Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center
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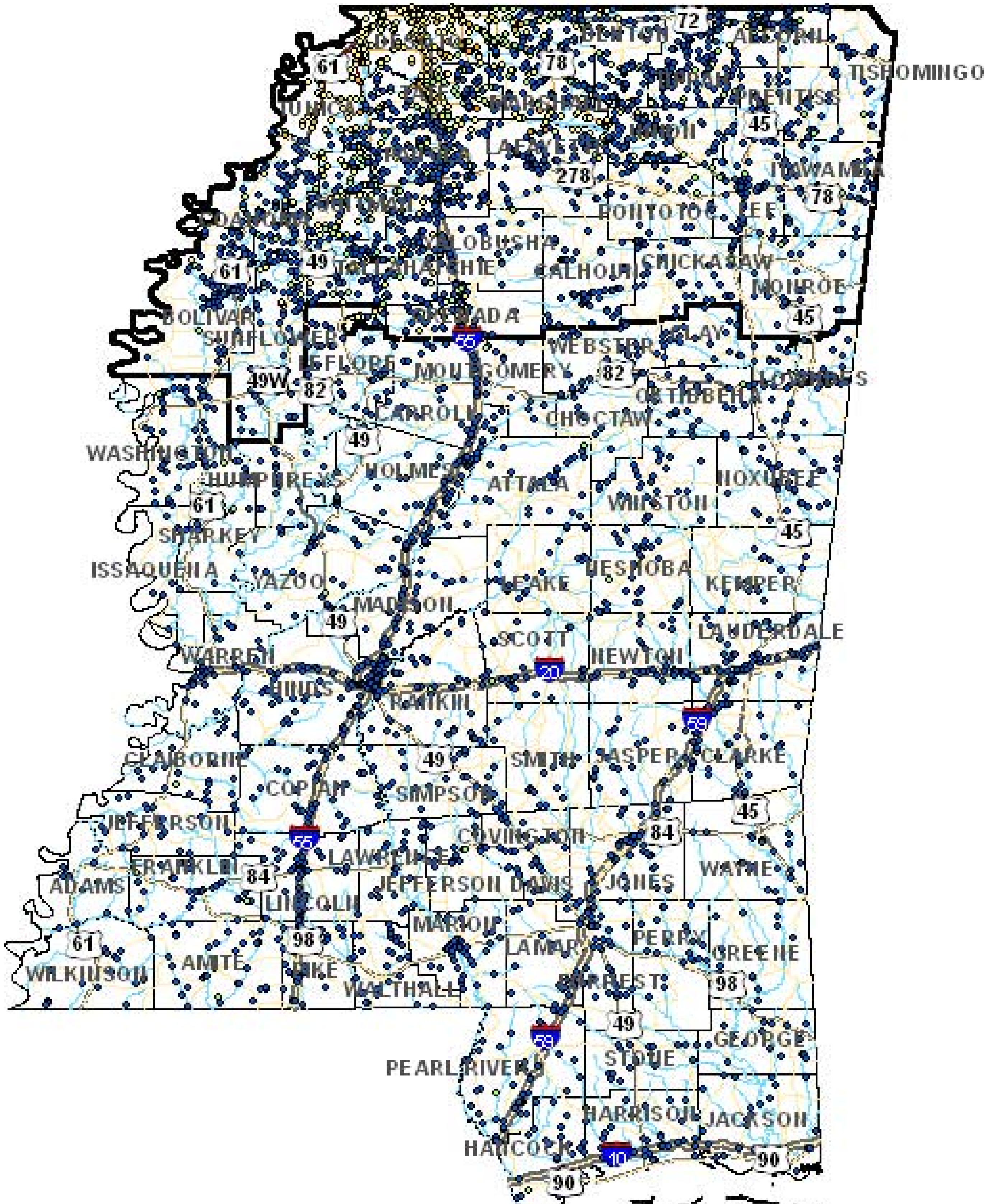
Theresa Jefferson, Principal Investigator

Highway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	234	0	0
Benton	120	1	0
Bolivar	286	0	0
Calhoun	224	0	0
Chickasaw	231	0	0
Coahoma	112	2	0
Desoto	204	25	0
Grenada	171	2	0
Itawamba	240	0	0
Lafayette	263	6	0
Lee	377	0	0
Marshall	256	6	0
Monroe	289	0	0
Panola	251	1	0
Pontotoc	164	0	0
Prentiss	206	0	0
Quitman	117	0	0
Sunflower	189	0	0
Tallahatchie	155	0	0
Tate	157	20	0
Tippah	175	1	0
Tishomingo	138	0	0
Tunica	63	9	0
Union	242	0	0
Yalobusha	179	0	0

Legend

Highway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Highway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60
Miles

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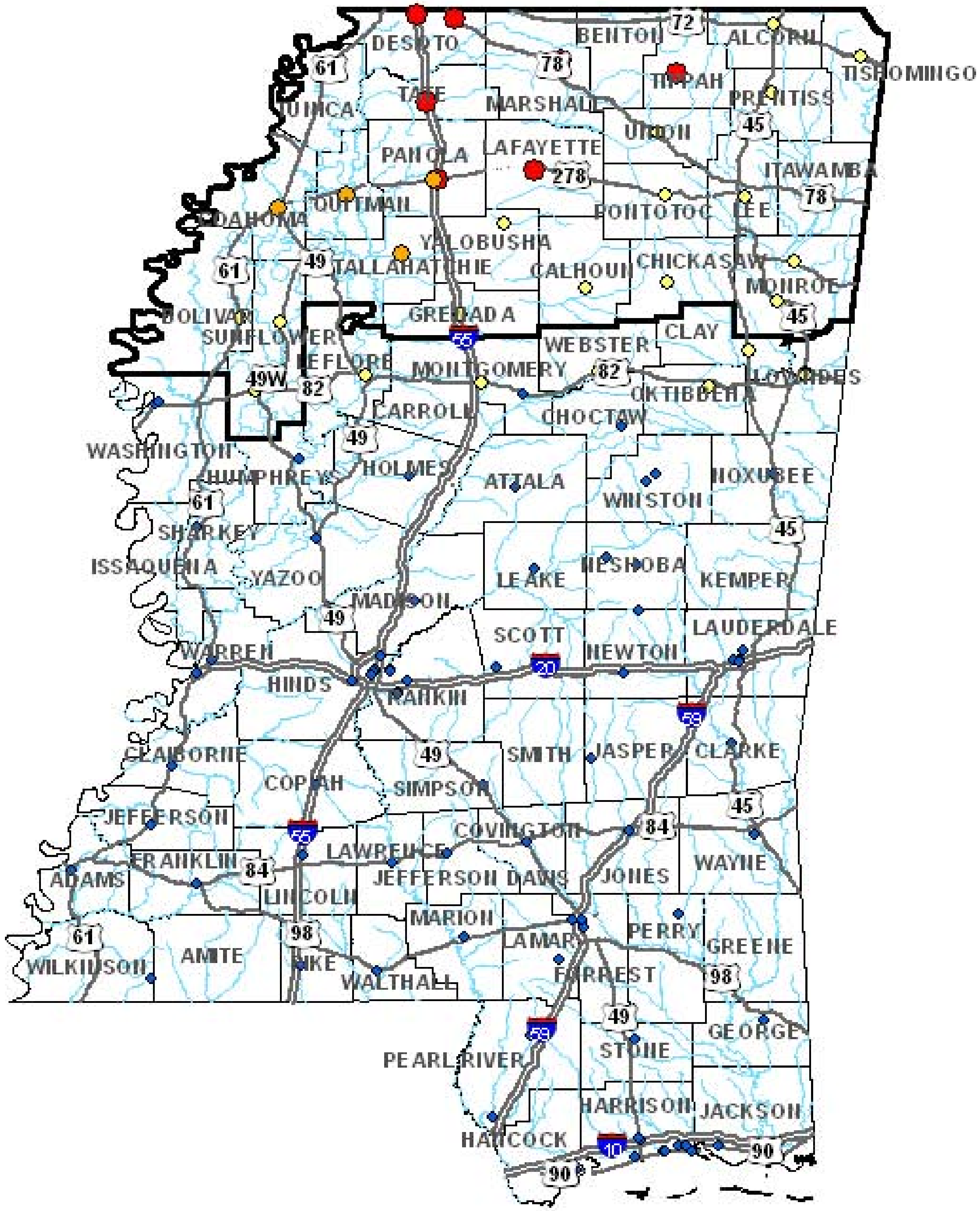
Hospital Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	1	0	0
Benton	0	0	0
Bolivar	1	0	0
Calhoun	1	0	0
Chickasaw	1	0	0
Coahoma	1	1	0
Desoto	2	2	2
Grenada	1	0	0
Itawamba	0	0	0
Lafayette	1	1	0
Lee	1	0	0
Marshall	1	1	0
Monroe	2	0	0
Panola	2	2	0
Pontotoc	1	0	0
Prentiss	1	0	0
Quitman	1	1	0
Sunflower	2	0	0
Tallahatchie	1	1	0
Tate	1	1	0
Tippah	1	1	0
Tishomingo	1	0	0
Tunica	0	0	0
Union	1	0	0
Yalobusha	1	0	0

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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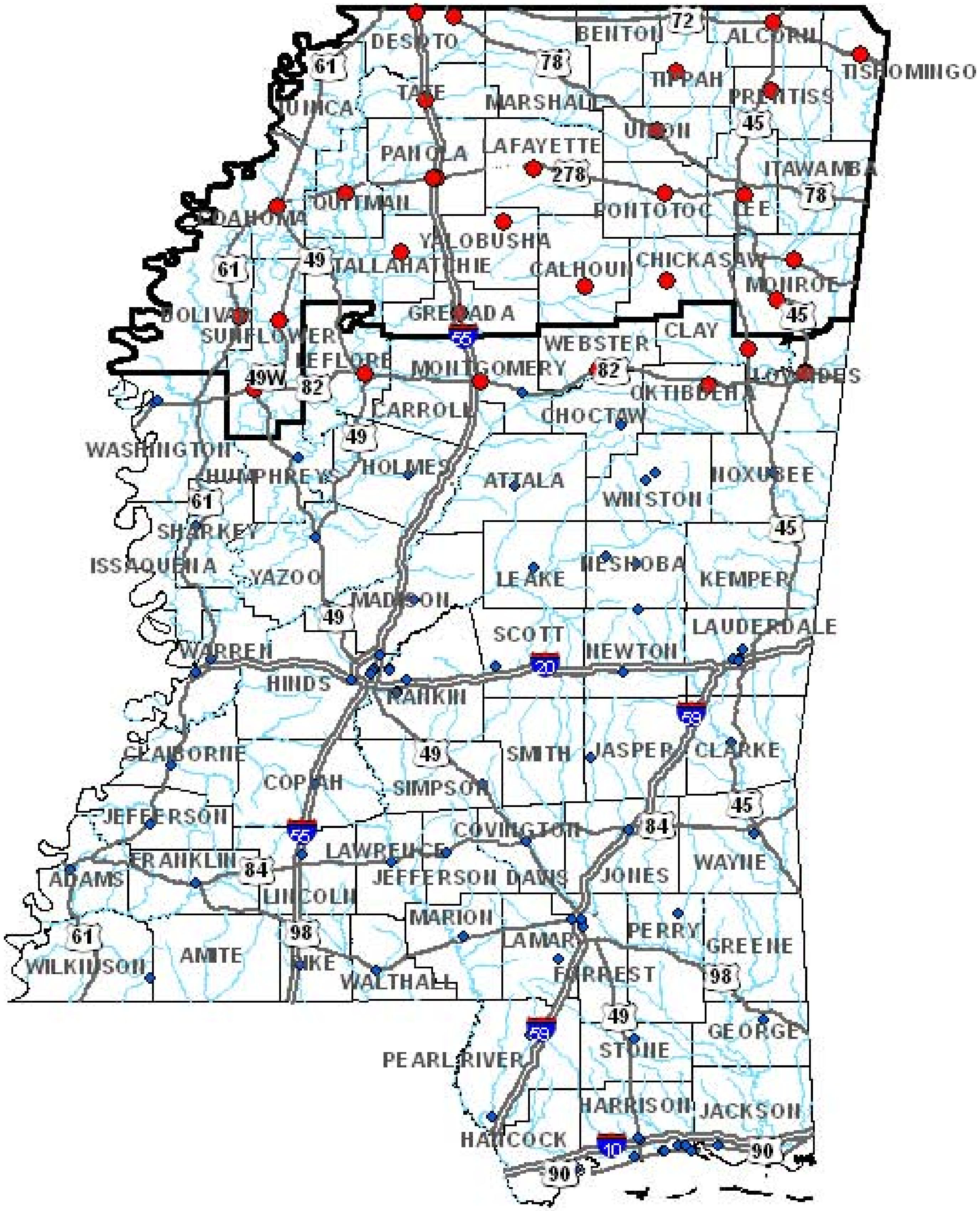
Hospital Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	0	1
Benton	0	0
Bolivar	0	1
Calhoun	0	1
Chickasaw	0	1
Coahoma	0	1
Desoto	0	2
Grenada	0	1
Itawamba	0	0
Lafayette	0	1
Lee	0	1
Marshall	0	1
Monroe	0	2
Panola	0	2
Pontotoc	0	1
Prentiss	0	1
Quitman	0	1
Sunflower	0	2
Tallahatchie	0	1
Tate	0	1
Tippah	0	1
Tishomingo	0	1
Tunica	0	0
Union	0	1
Yalobusha	0	1

Legend

Hospital Functionality

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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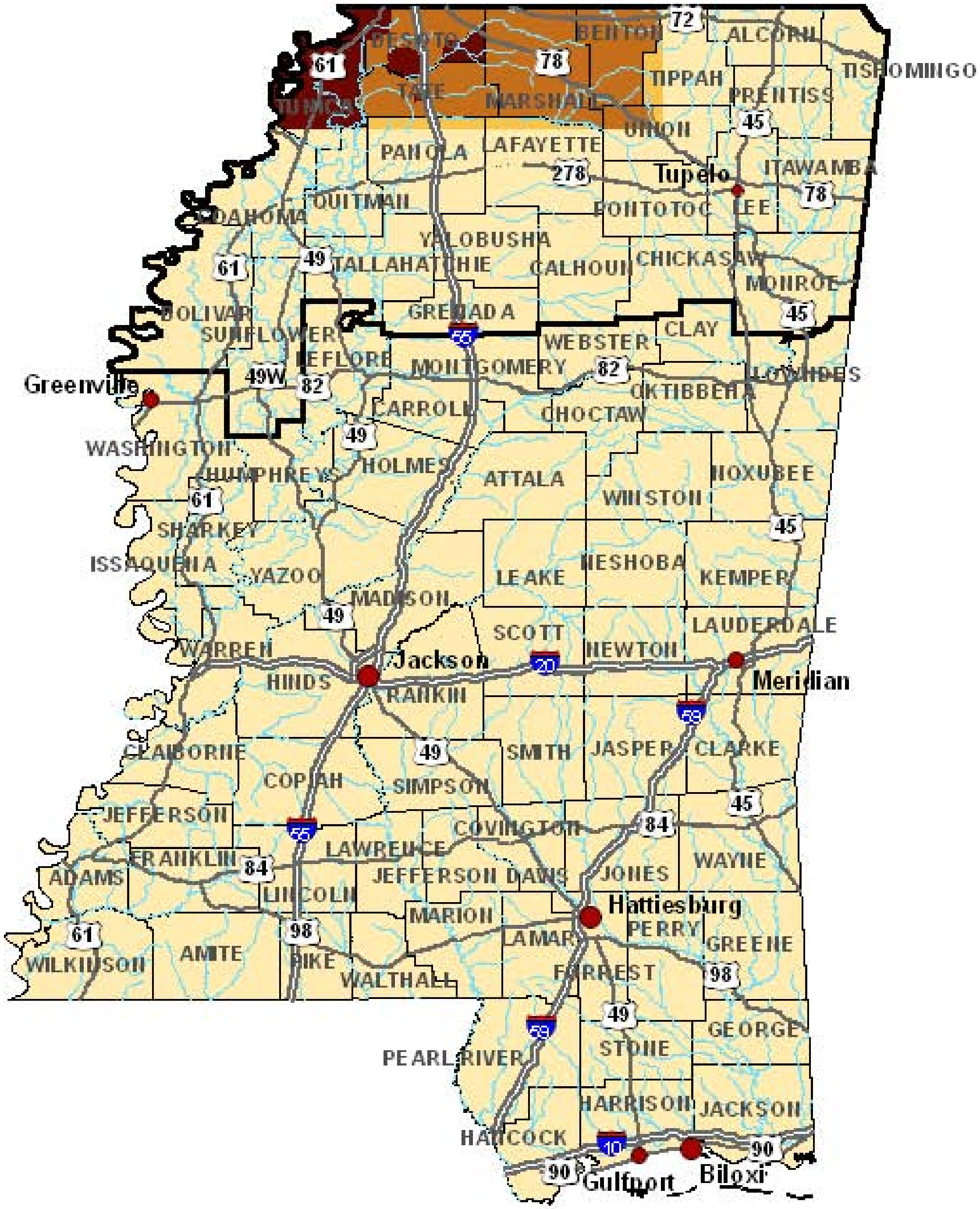
Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Minimum Susceptibility	Maximum Susceptibility
Alcorn	Unknown	Unknown
Benton	Unknown	Low
Bolivar	Unknown	Unknown
Calhoun	Unknown	Unknown
Chickasaw	Unknown	Unknown
Coahoma	Unknown	None
Desoto	Unknown	Very High
Grenada	Unknown	Unknown
Itawamba	Unknown	Unknown
Lafayette	Unknown	None
Lee	Unknown	Unknown
Marshall	Unknown	Low
Monroe	Unknown	Unknown
Panola	Unknown	None
Pontotoc	Unknown	Unknown
Prentiss	Unknown	Unknown
Quitman	Unknown	None
Sunflower	Unknown	Unknown
Tallahatchie	Unknown	Unknown
Tate	Low	Very High
Tippah	Unknown	None
Tishomingo	Unknown	Unknown
Tunica	Unknown	Very High
Union	Unknown	Low
Yalobusha	Unknown	Unknown

Legend

Liquefaction Susceptibility

- Unknown
- None
- Low
- Very High

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000

- US Routes
- Critical Counties
- Interstates
- Rivers

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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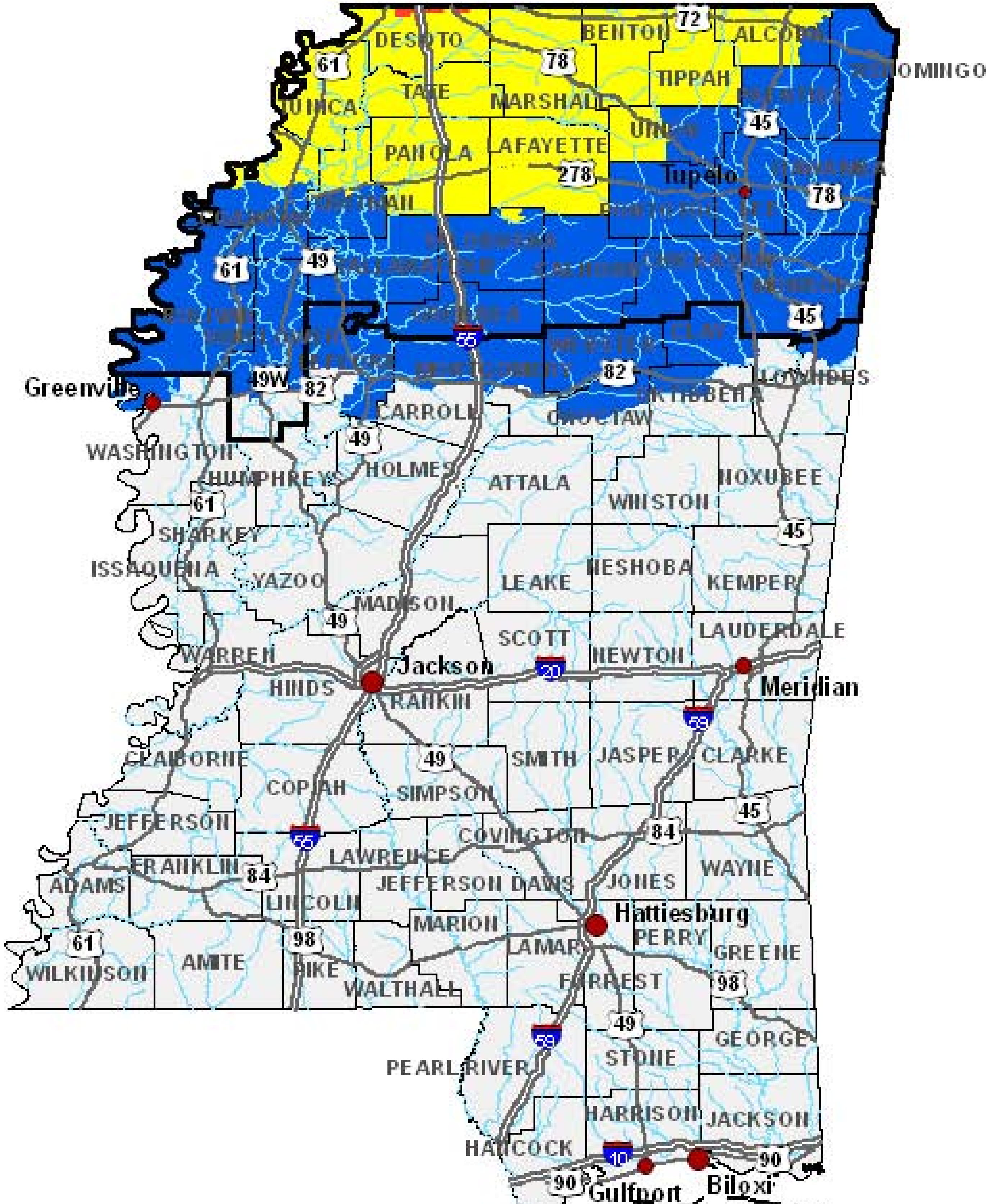
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Max. MMI
Alcorn	VII
Benton	VII
Bolivar	VI
Calhoun	VI
Chickasaw	VI
Coahoma	VII
Desoto	VIII
Grenada	VI
Itawamba	VI
Lafayette	VII
Lee	VI
Marshall	VII
Monroe	VI
Panola	VII
Pontotoc	VI
Prentiss	VI
Quitman	VII
Sunflower	VI
Tallahatchie	VI
Tate	VII
Tippah	VII
Tishomingo	VI
Tunica	VII
Union	VII
Yalobusha	VII

Legend

Modified Mercalli Intensity

- < VI
- VI
- VII
- VIII
- US Routes
- Interstates
- Critical Counties
- Rivers

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000

0 10 20 40 60
Miles

Mid-America Earthquake Center

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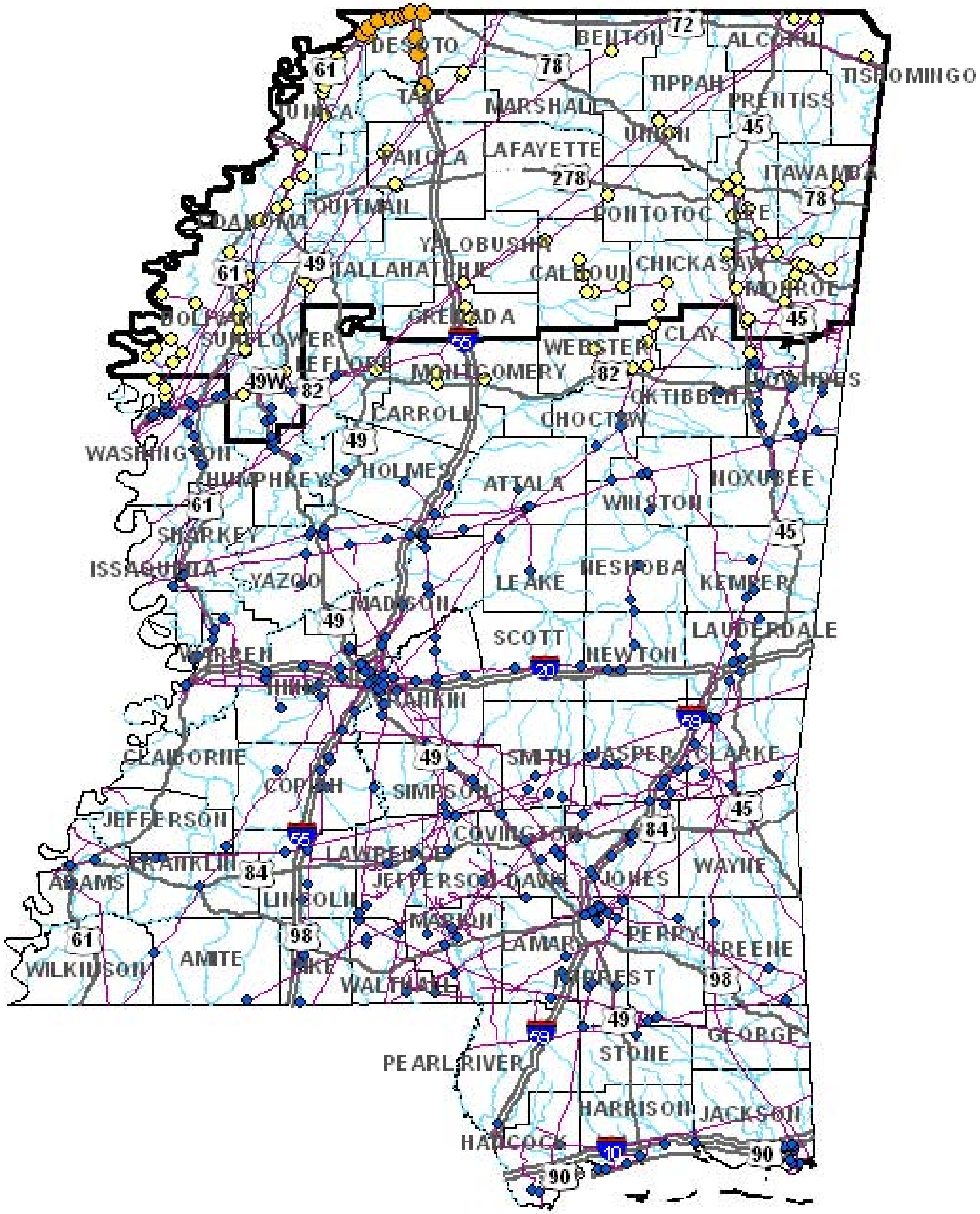
Natural Gas Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	2	0	0
Benton	1	0	0
Bolivar	16	0	0
Calhoun	6	0	0
Chickasaw	3	0	0
Coahoma	7	0	0
Desoto	11	11	0
Grenada	2	0	0
Itawamba	1	0	0
Lafayette	0	0	0
Lee	7	0	0
Marshall	0	0	0
Monroe	12	0	0
Panola	5	0	0
Pontotoc	1	0	0
Prentiss	0	0	0
Quitman	0	0	0
Sunflower	8	0	0
Tallahatchie	2	0	0
Tate	4	1	0
Tippah	0	0	0
Tishomingo	1	0	0
Tunica	5	0	0
Union	3	0	0
Yalobusha	1	0	0

Legend

Natural Gas Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Major Natural Gas Lines
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

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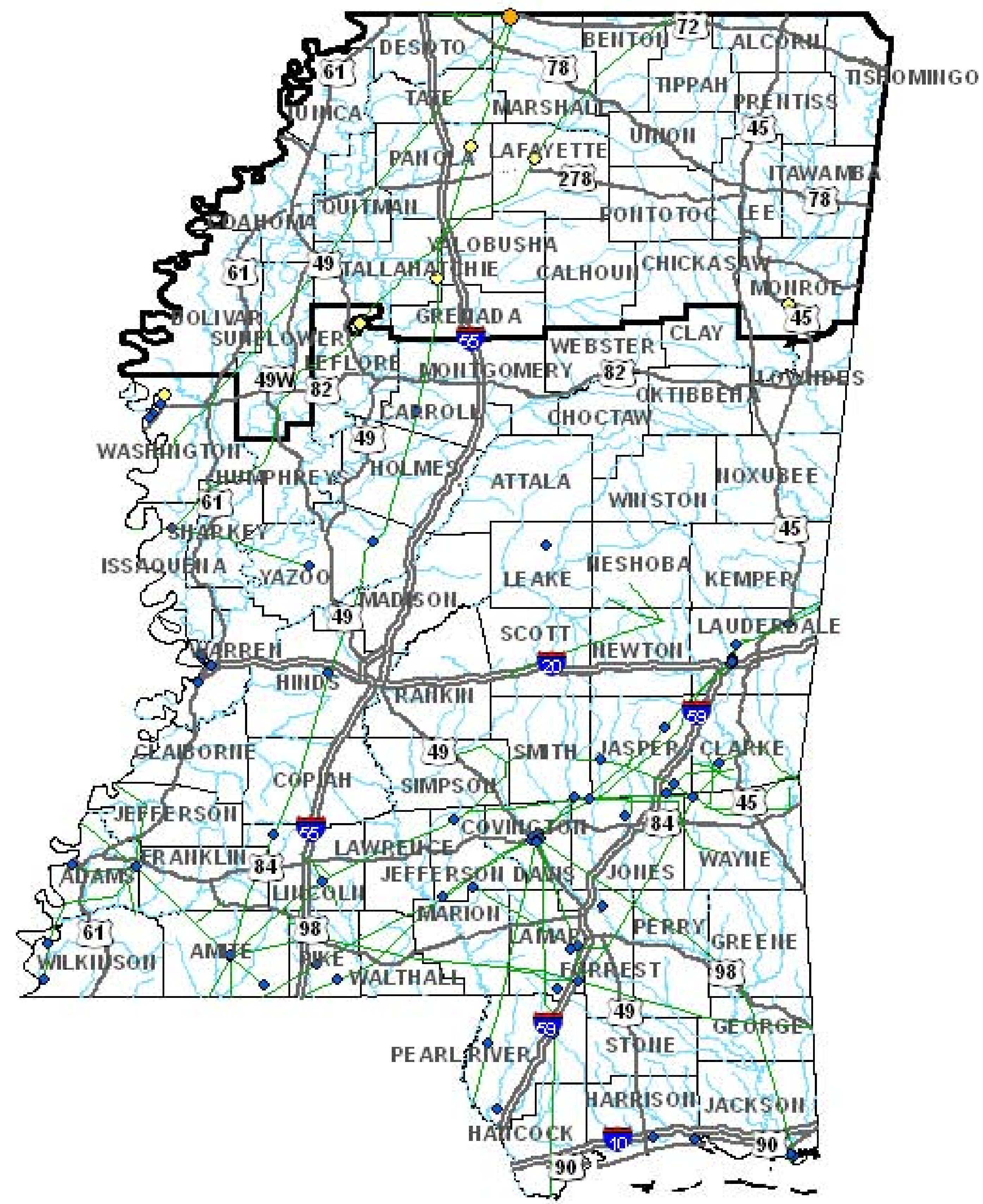
Oil Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	0	0	0
Benton	0	0	0
Bolivar	0	0	0
Calhoun	0	0	0
Chickasaw	0	0	0
Coahoma	0	0	0
Desoto	0	0	0
Grenada	0	0	0
Itawamba	0	0	0
Lafayette	1	0	0
Lee	0	0	0
Marshall	1	1	0
Monroe	1	0	0
Panola	1	0	0
Pontotoc	0	0	0
Prentiss	0	0	0
Quitman	0	0	0
Sunflower	0	0	0
Tallahatchie	2	0	0
Tate	0	0	0
Tippah	0	0	0
Tishomingo	0	0	0
Tunica	0	0	0
Union	0	0	0
Yalobusha	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Major Oil Transmission Lines
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

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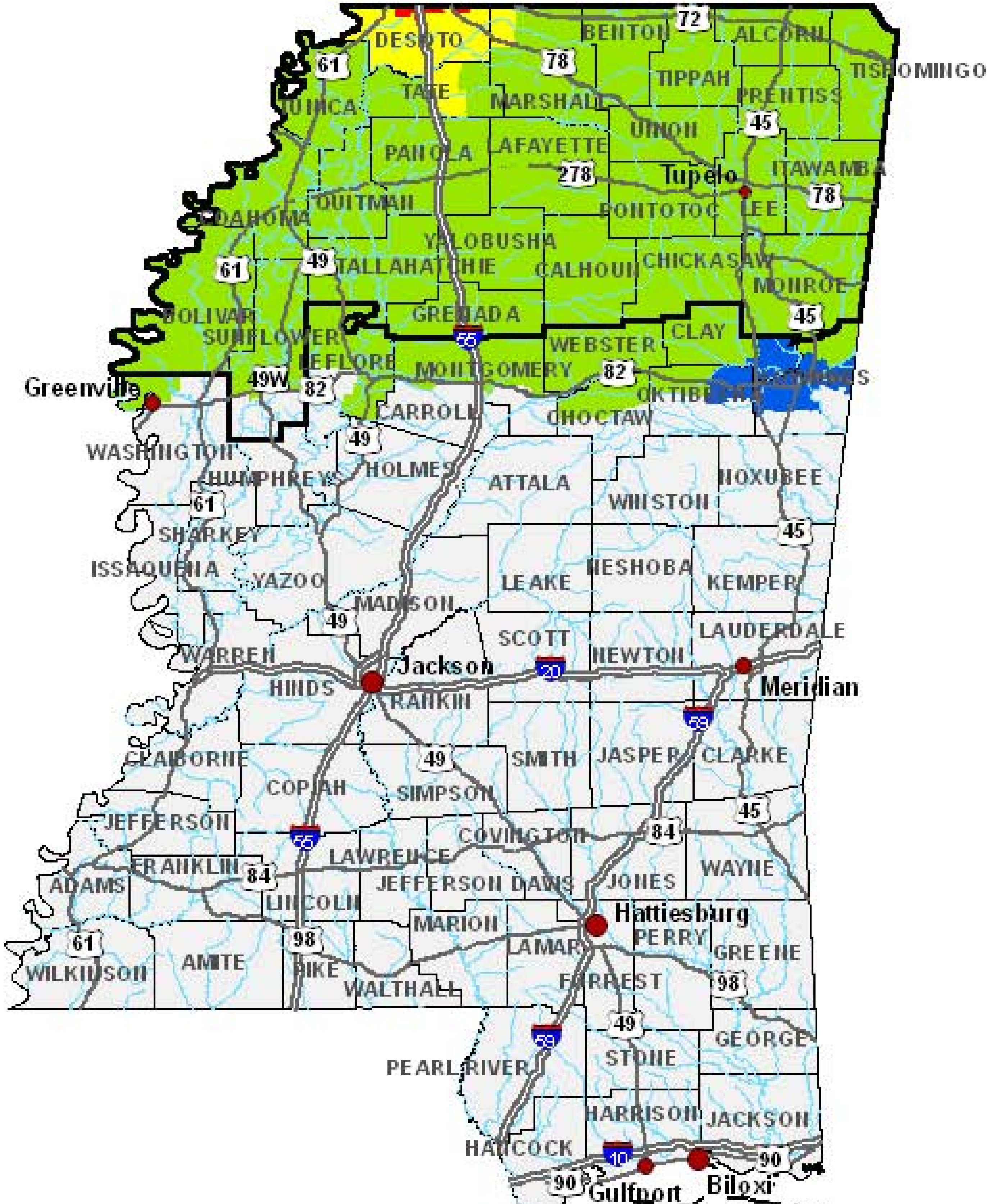
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Min. PGA	Max. PGA
Alcorn	0.15	0.25
Benton	0.25	0.25
Bolivar	0.05	0.15
Calhoun	0.15	0.15
Chickasaw	0.15	0.15
Coahoma	0.15	0.25
Desoto	0.25	0.44
Grenada	0.15	0.15
Itawamba	0.15	0.15
Lafayette	0.15	0.25
Lee	0.15	0.15
Marshall	0.25	0.34
Monroe	0.15	0.15
Panola	0.25	0.25
Pontotoc	0.15	0.15
Prentiss	0.15	0.15
Quitman	0.15	0.25
Sunflower	0.05	0.15
Tallahatchie	0.15	0.15
Tate	0.25	0.34
Tippah	0.25	0.25
Tishomingo	0.15	0.15
Tunica	0.25	0.25
Union	0.15	0.25
Yalobusha	0.15	0.25

Legend

PGA (g)
- 0.0 - 0.06
- 0.06 - 0.15
- 0.15 - 0.25
- 0.25 - 0.35
- 0.35 - 0.45
- US Routes
- Interstates
- Critical Counties
- Rivers

Major Cities
- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000

0 10 20 40 60
Miles

Mid-America Earthquake Center

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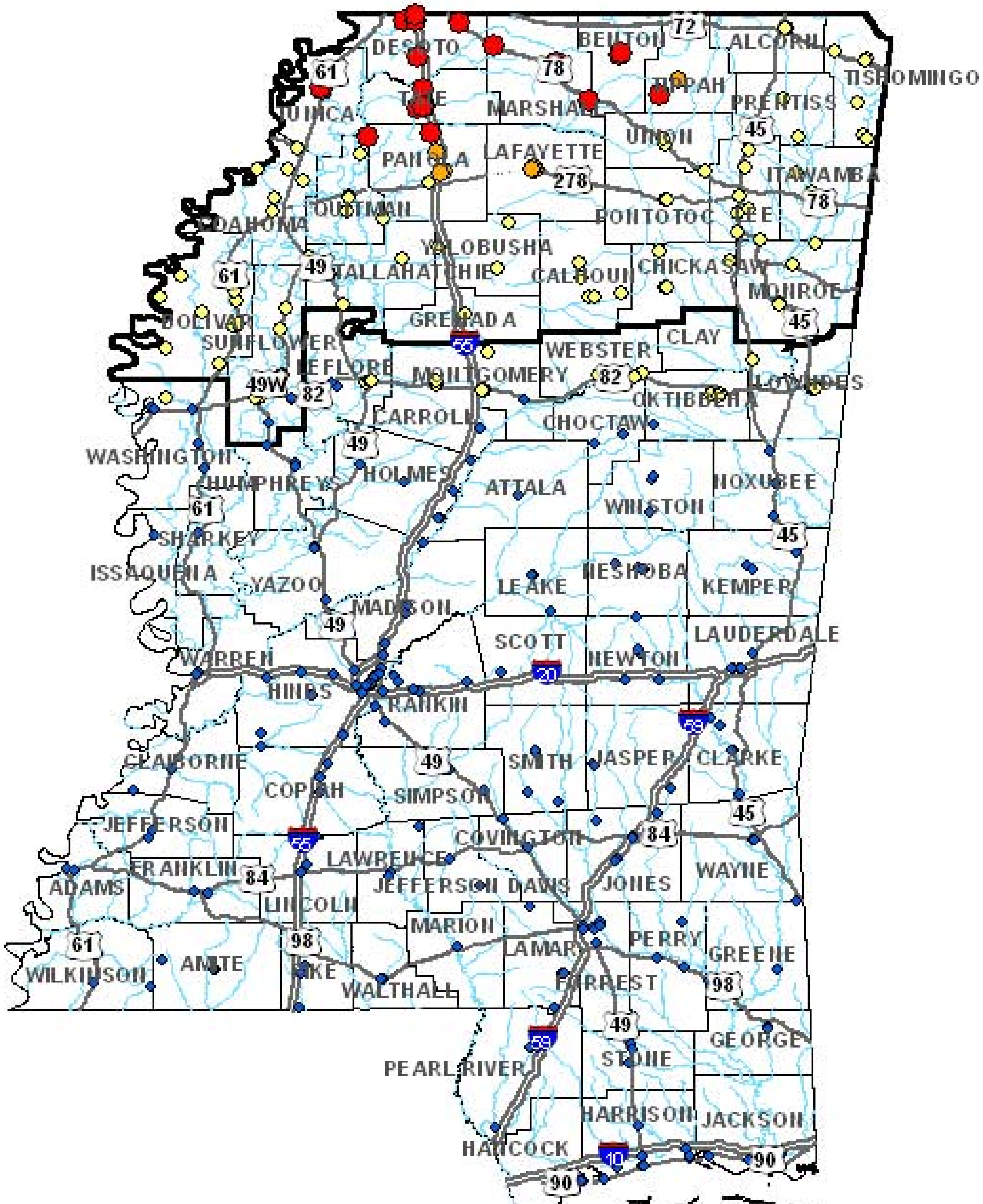
Police Station Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	2	0	0
Benton	2	2	0
Bolivar	13	0	0
Calhoun	5	0	0
Chickasaw	4	0	0
Coahoma	7	0	0
Desoto	6	6	2
Grenada	2	0	0
Itawamba	4	0	0
Lafayette	3	3	0
Lee	7	0	0
Marshall	4	4	0
Monroe	5	0	0
Panola	6	5	0
Pontotoc	3	0	0
Prentiss	4	0	0
Quitman	5	0	0
Sunflower	8	0	0
Tallahatchie	7	0	0
Tate	4	4	0
Tippah	4	4	0
Tishomingo	6	0	0
Tunica	2	2	0
Union	4	0	0
Yalobusha	4	0	0

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center

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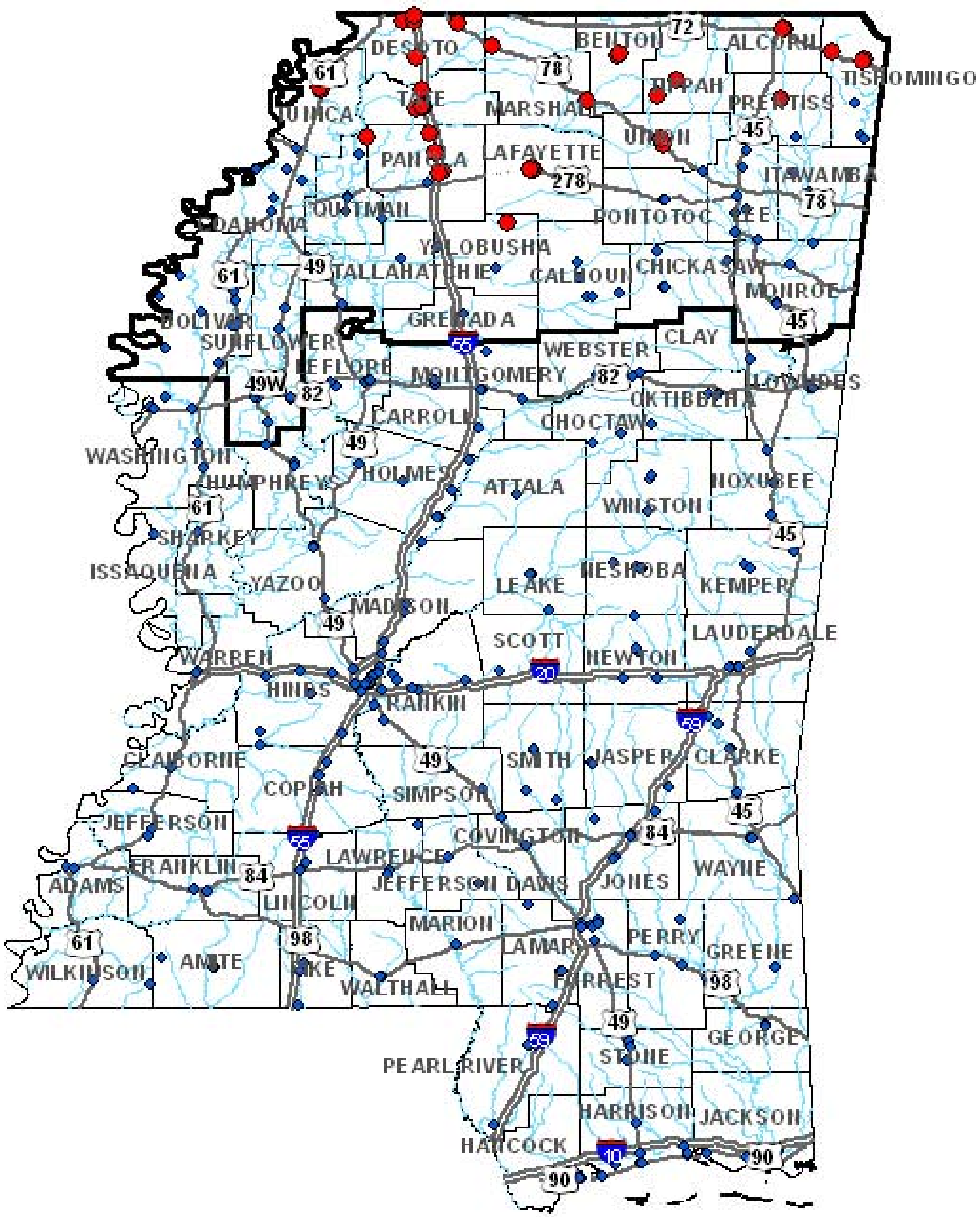
Police Station Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	0	2
Benton	0	2
Bolivar	13	13
Calhoun	5	5
Chickasaw	4	4
Coahoma	7	7
Desoto	0	6
Grenada	2	2
Itawamba	4	4
Lafayette	0	3
Lee	7	7
Marshall	0	4
Monroe	5	5
Panola	1	6
Pontotoc	3	3
Prentiss	2	4
Quitman	5	5
Sunflower	8	8
Tallahatchie	7	7
Tate	0	4
Tippah	0	4
Tishomingo	3	6
Tunica	0	2
Union	0	4
Yalobusha	2	4

Legend

Police Station Functionality

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center

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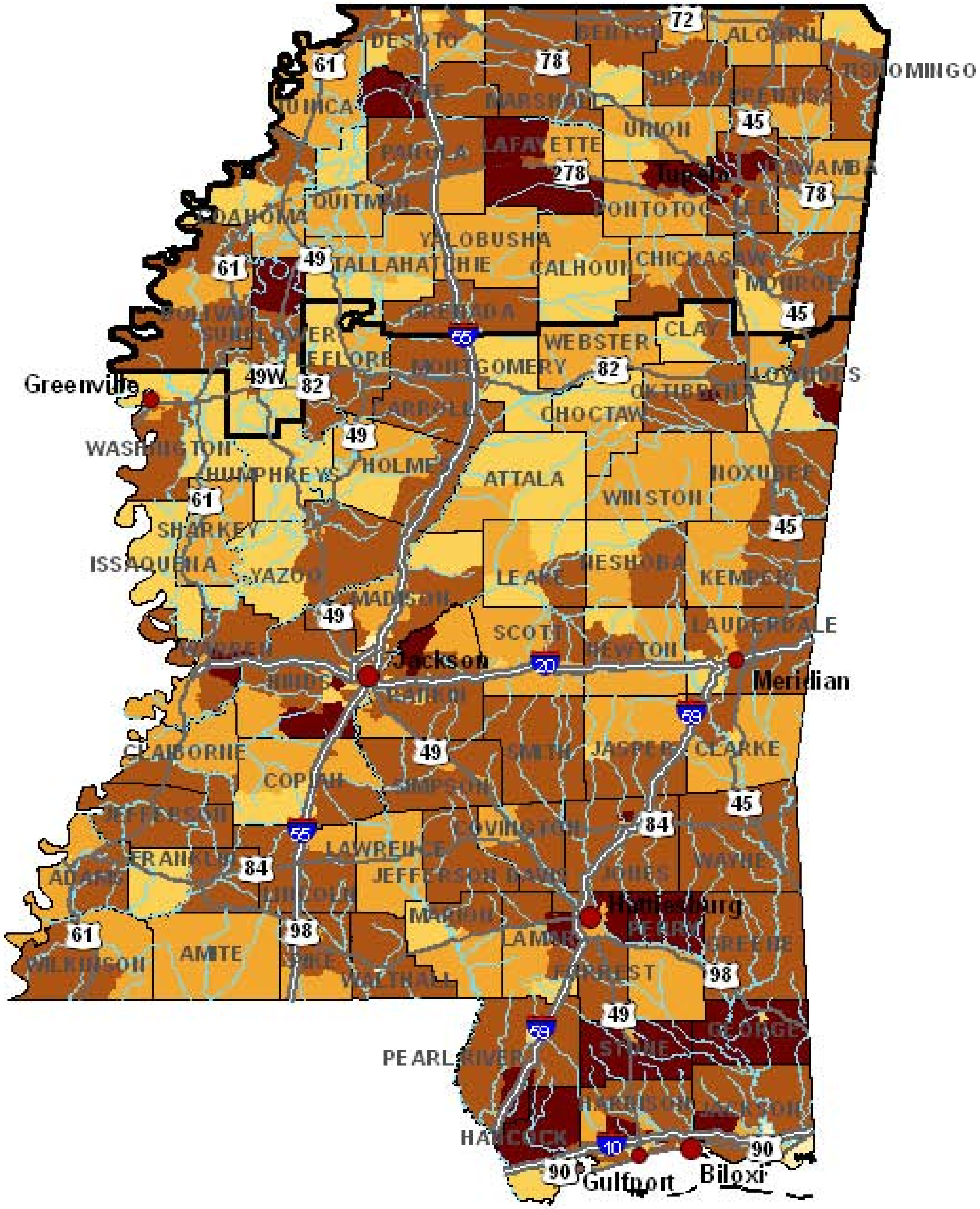
Total Population (2000) - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Population
Alcorn	34,558
Benton	14,902
Bolivar	48,283
Calhoun	18,689
Chickasaw	28,460
Coahoma	30,622
Desoto	115,699
Grenada	23,263
Itawamba	22,770
Lafayette	43,688
Lee	75,755
Marshall	34,993
Monroe	45,894
Panola	34,274
Pontotoc	26,726
Prentiss	25,556
Quitman	10,117
Sunflower	34,369
Tallahatchie	14,903
Tate	43,190
Tippah	20,826
Tishomingo	19,163
Tunica	17,727
Union	25,362
Yalobusha	13,051

Legend

Total Population

(HAZUS 2000)

- 0 - 2,000
- 2,001 - 3,500
- 3,501 - 5,000
- 5,001 - 8,000
- 8,001 - 12,000
- US Routes
- Interstates
- Critical Counties
- Rivers

Major Cities

- 30,000 - 40,000
- 40,001 - 45,000
- 45,001 - 194,000

0 10 20 40 60

Miles

Mid-America Earthquake Center

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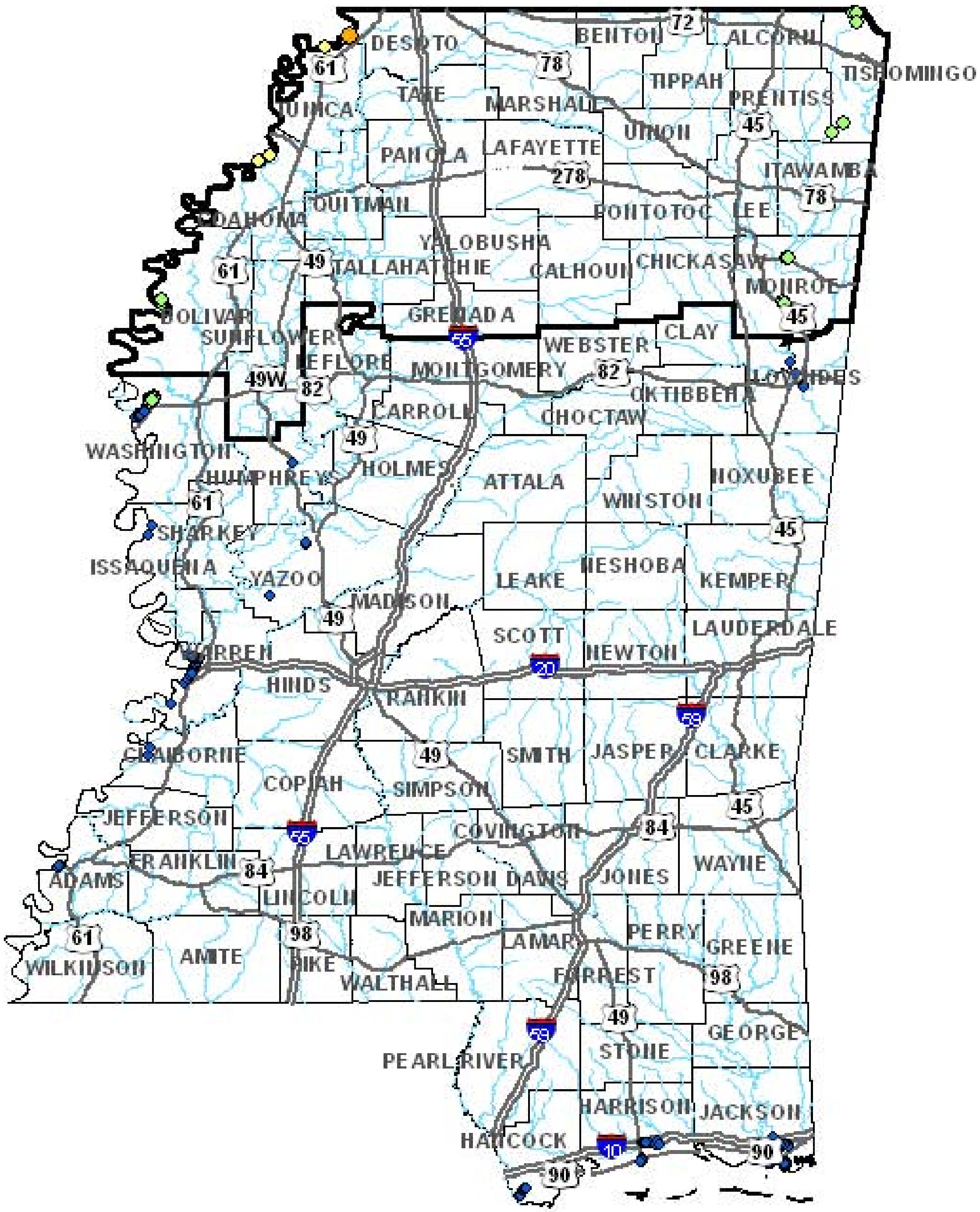
Port Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	0	0	0
Benton	0	0	0
Bolivar	4	0	0
Calhoun	0	0	0
Chickasaw	0	0	0
Coahoma	4	0	0
Desoto	1	1	0
Grenada	0	0	0
Itawamba	3	0	0
Lafayette	0	0	0
Lee	0	0	0
Marshall	0	0	0
Monroe	7	0	0
Panola	0	0	0
Pontotoc	0	0	0
Prentiss	0	0	0
Quitman	0	0	0
Sunflower	0	0	0
Tallahatchie	0	0	0
Tate	0	0	0
Tippah	0	0	0
Tishomingo	7	0	0
Tunica	1	0	0
Union	0	0	0
Yalobusha	0	0	0

Legend

Port Facility Damage

At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

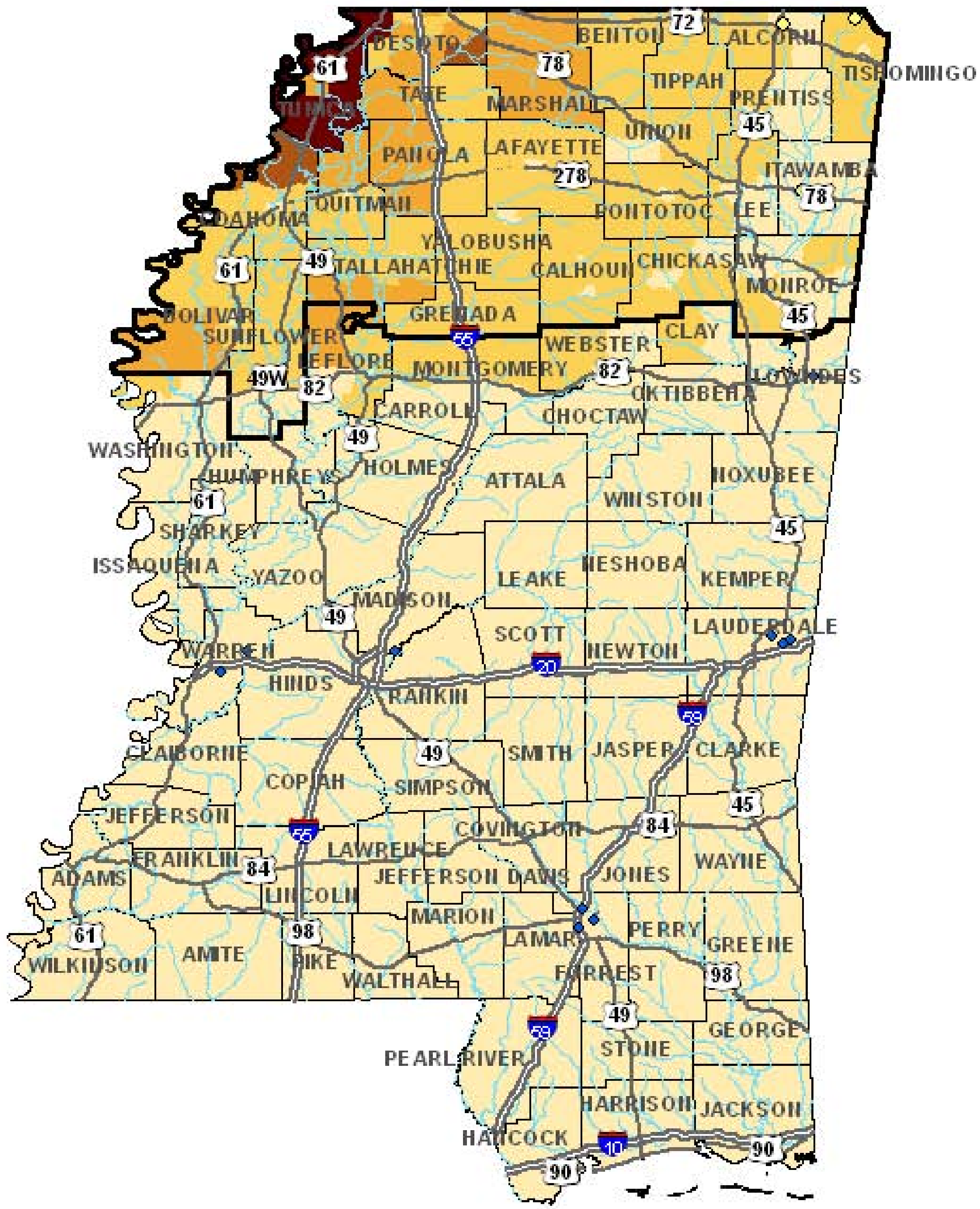
Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Potable Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	1	0	0
Benton	0	0	0
Bolivar	0	0	0
Calhoun	0	0	0
Chickasaw	0	0	0
Coahoma	0	0	0
Desoto	0	0	0
Grenada	0	0	0
Itawamba	1	0	0
Lafayette	0	0	0
Lee	0	0	0
Marshall	0	0	0
Monroe	0	0	0
Panola	0	0	0
Pontotoc	0	0	0
Prentiss	0	0	0
Quitman	0	0	0
Sunflower	0	0	0
Tallahatchie	0	0	0
Tate	0	0	0
Tippah	0	0	0
Tishomingo	1	0	0
Tunica	0	0	0
Union	0	0	0
Yalobusha	0	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Potable Water Distribution Lines

No. of Leaks

- 0 - 6
- 6 - 25
- 25 - 75
- 75 - 150
- 150 - 335

US Routes
Interstates
Rivers
Critical Counties

0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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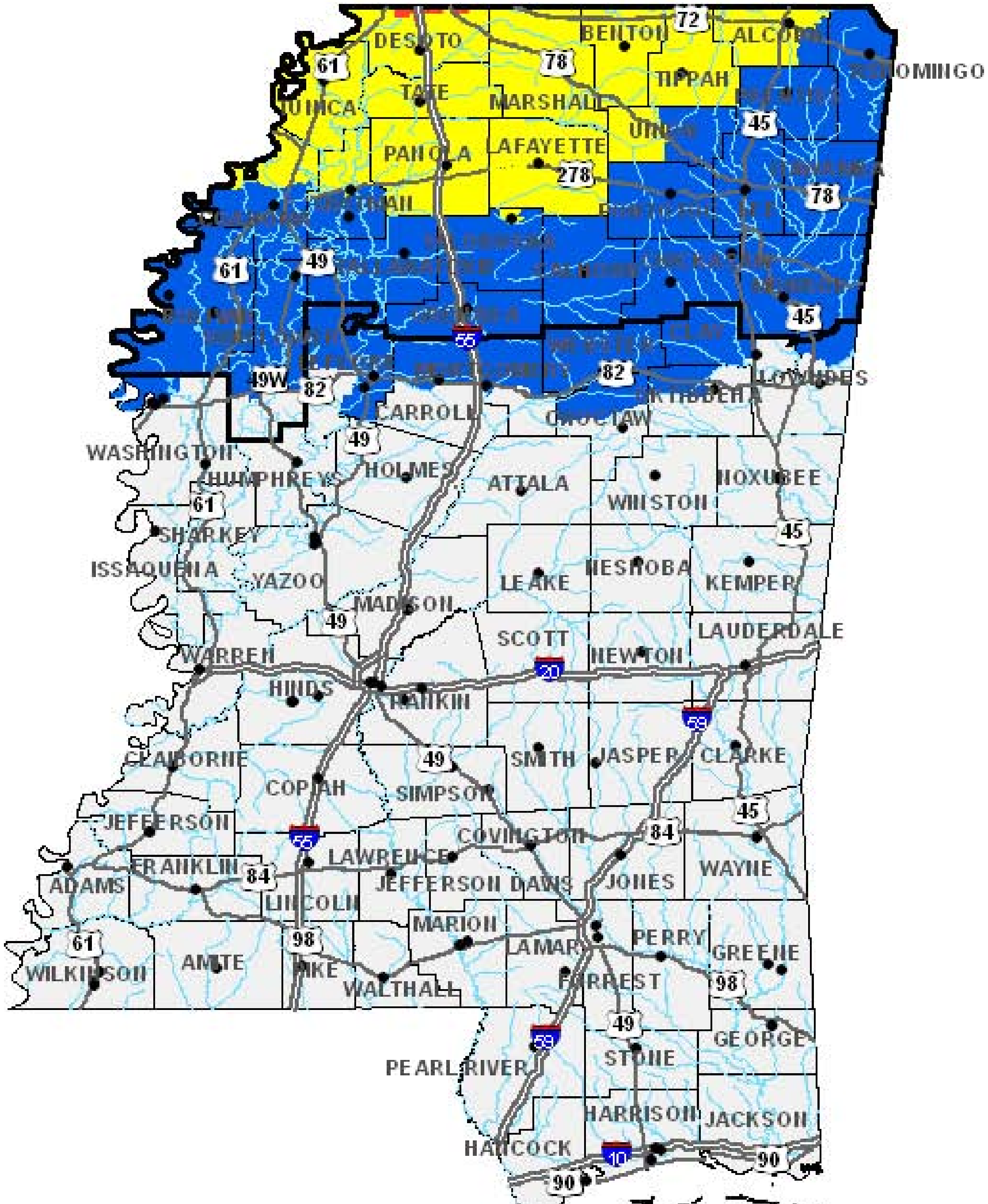
Prisons - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Facilities
Alcorn	1
Benton	1
Bolivar	2
Calhoun	1
Chickasaw	2
Coahoma	1
Desoto	1
Grenada	1
Itawamba	1
Lafayette	1
Lee	1
Marshall	2
Monroe	1
Panola	1
Pontotoc	1
Prentiss	1
Quitman	2
Sunflower	1
Tallahatchie	2
Tate	1
Tippah	1
Tishomingo	1
Tunica	1
Union	0
Yalobusha	1

Legend

- Prisons

Modified Mercalli Intensity

- < VI
- VI
- VII
- VIII
- US Routes
- Interstates
- Critical Counties
- Rivers

0 10 20 40 60
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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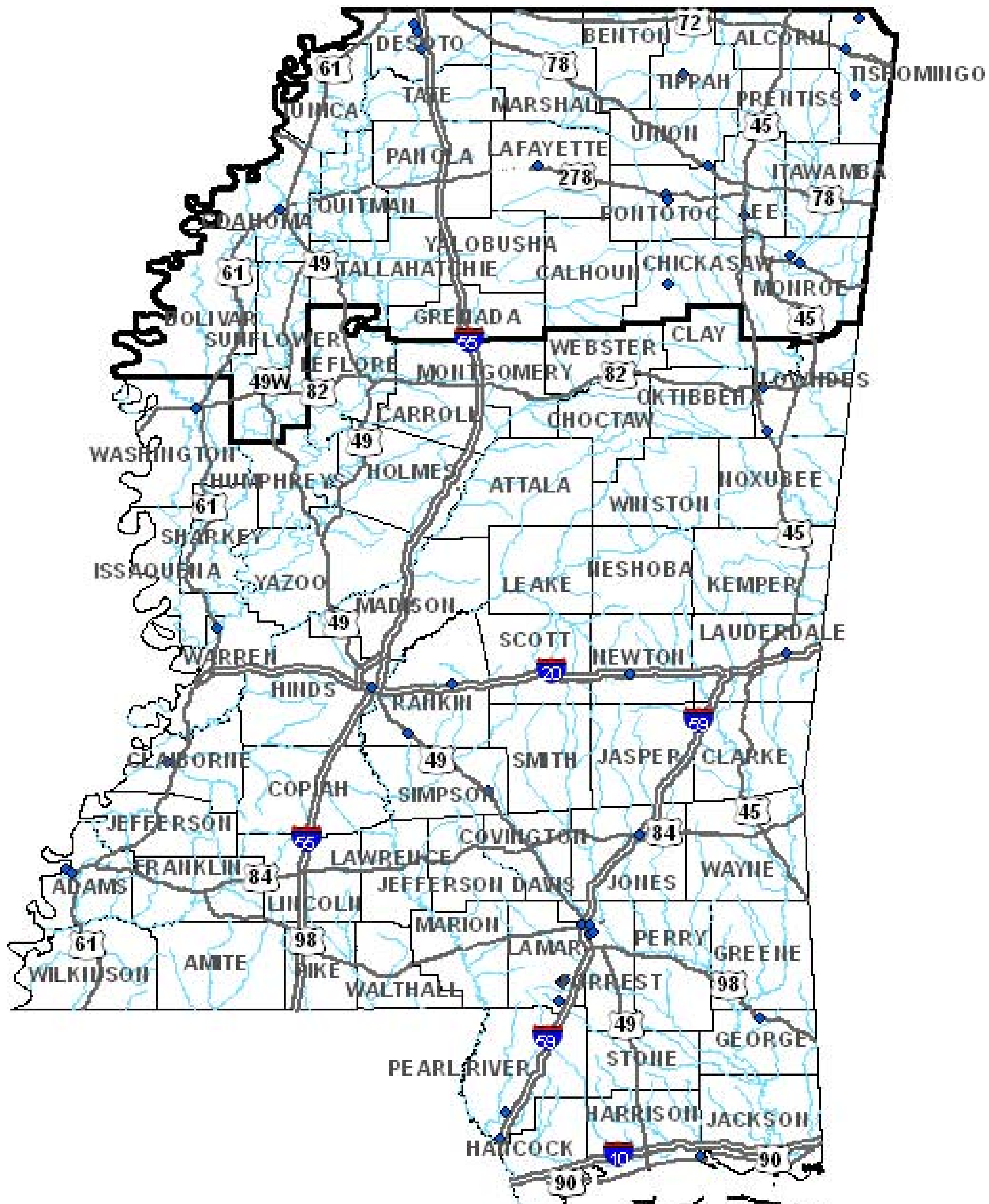
Railway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	0	0	0
Benton	0	0	0
Bolivar	0	0	0
Calhoun	0	0	0
Chickasaw	2	0	0
Coahoma	1	0	0
Desoto	3	0	0
Grenada	0	0	0
Itawamba	0	0	0
Lafayette	2	0	0
Lee	2	0	0
Marshall	2	0	0
Monroe	2	0	0
Panola	0	0	0
Pontotoc	3	0	0
Prentiss	0	0	0
Quitman	0	0	0
Sunflower	0	0	0
Tallahatchie	0	0	0
Tate	0	0	0
Tippah	1	0	0
Tishomingo	4	0	0
Tunica	0	0	0
Union	1	0	0
Yalobusha	0	0	0

Legend

Railway Bridge Functionality

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

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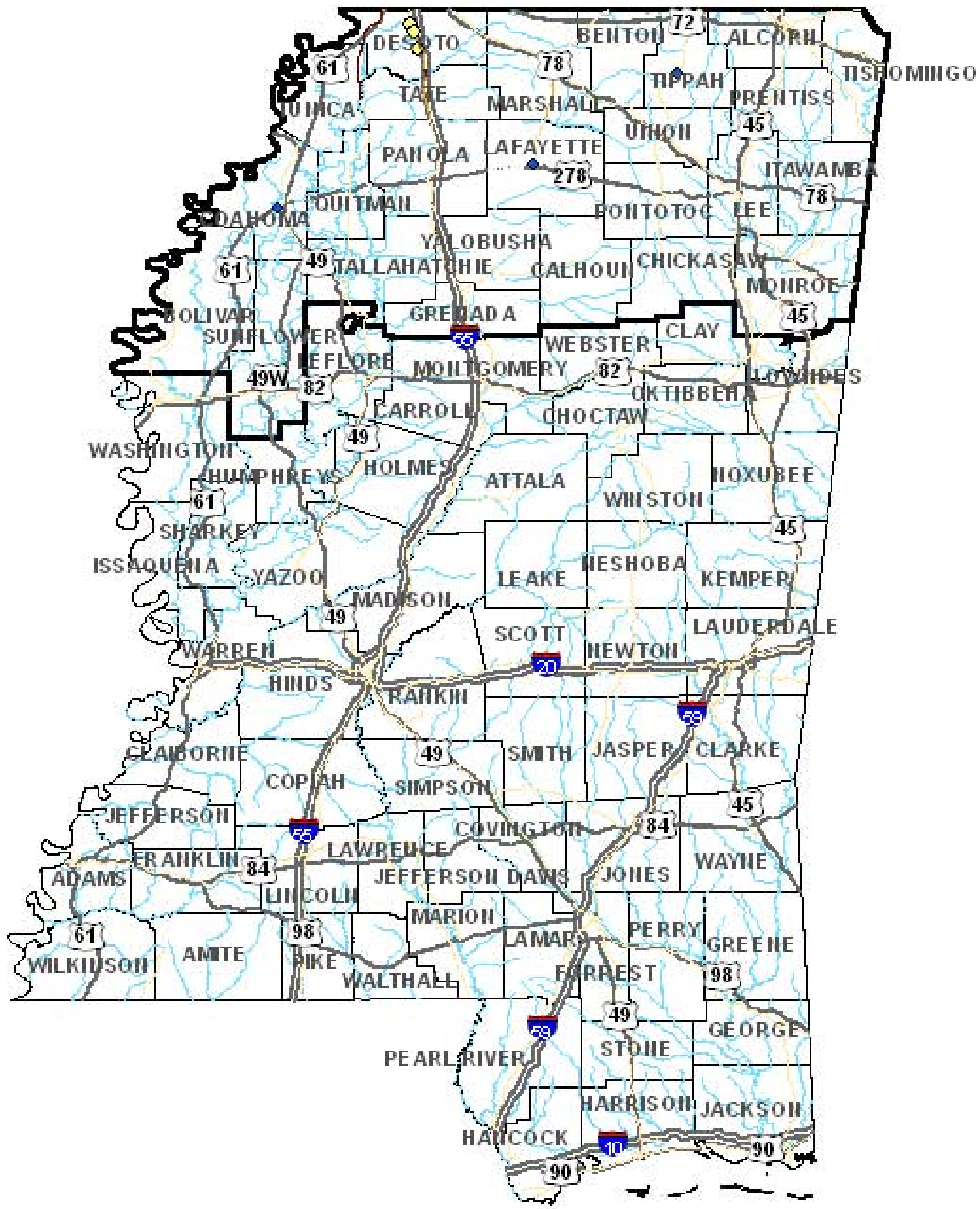
Railway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	0	0
Benton	0	0
Bolivar	0	0
Calhoun	0	0
Chickasaw	2	2
Coahoma	1	1
Desoto	3	3
Grenada	0	0
Itawamba	0	0
Lafayette	2	2
Lee	2	2
Marshall	2	2
Monroe	2	2
Panola	0	0
Pontotoc	3	3
Prentiss	0	0
Quitman	0	0
Sunflower	0	0
Tallahatchie	0	0
Tate	0	0
Tippah	1	1
Tishomingo	4	4
Tunica	0	0
Union	1	1
Yalobusha	0	0

Legend

Railway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Railway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

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Mid-America Earthquake Center

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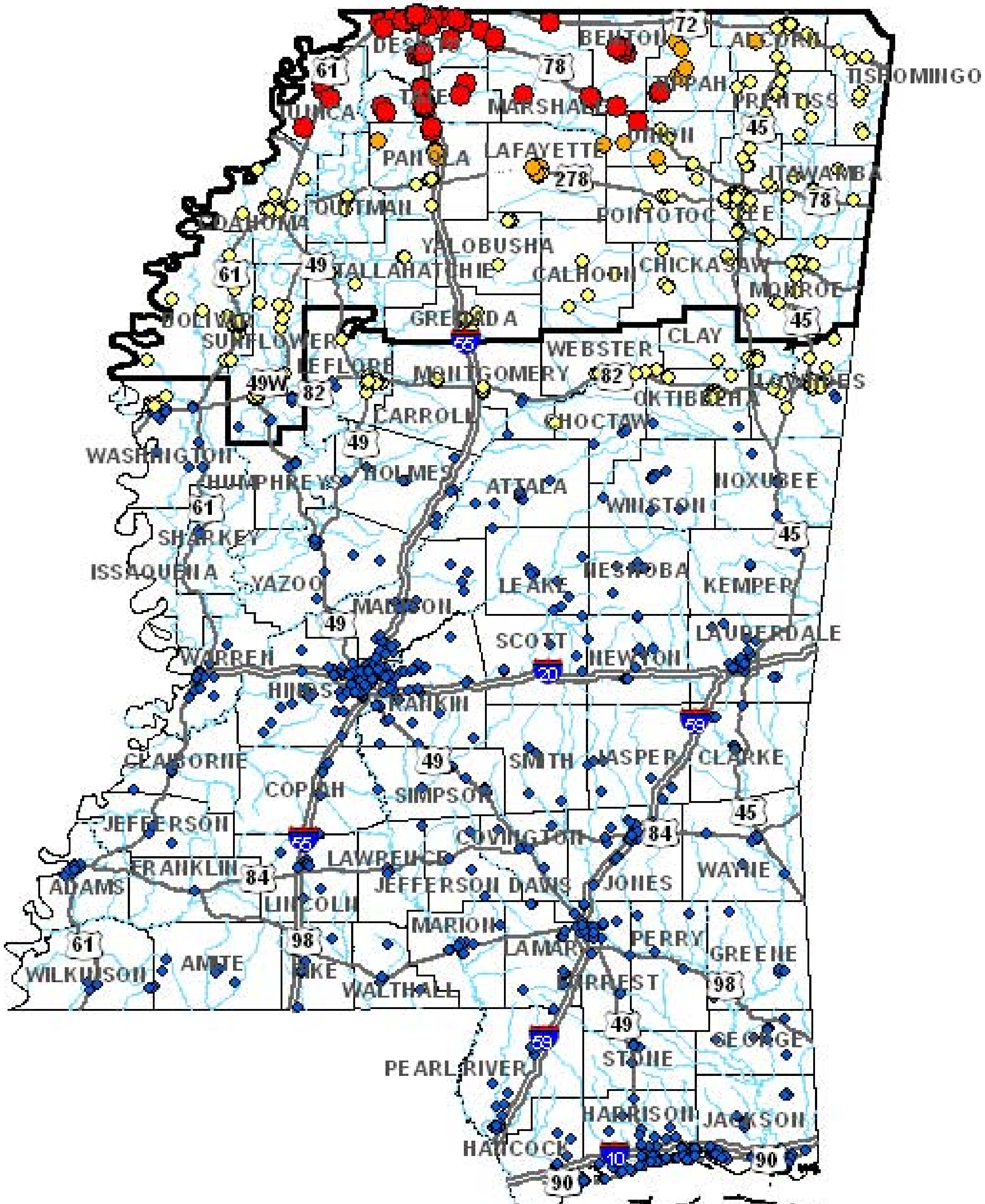
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

School Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	17	3	0
Benton	5	5	0
Bolivar	25	0	0
Calhoun	8	0	0
Chickasaw	9	0	0
Coahoma	23	0	0
Desoto	35	35	10
Grenada	7	0	0
Itawamba	9	0	0
Lafayette	15	10	0
Lee	32	0	0
Marshall	16	16	0
Monroe	19	0	0
Panola	15	7	0
Pontotoc	13	0	0
Prentiss	15	0	0
Quitman	5	0	0
Sunflower	24	0	0
Tallahatchie	7	0	0
Tate	13	13	0
Tippah	12	12	0
Tishomingo	9	0	0
Tunica	6	6	0
Union	9	3	0
Yalobusha	5	0	0

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

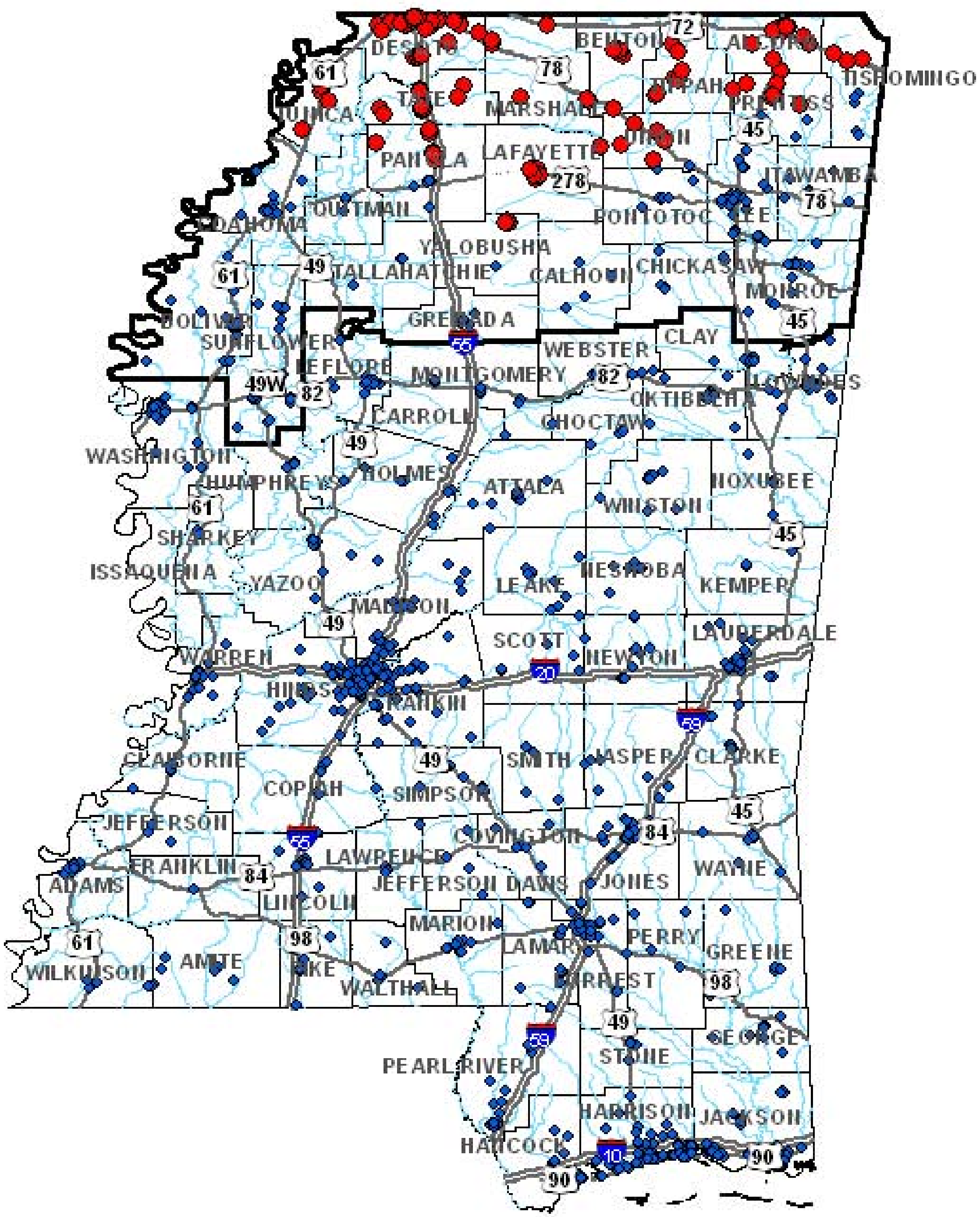
Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

School Functionality - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	No. of Functional Facilities	Total No. of Facilities
Alcorn	0	17
Benton	0	5
Bolivar	25	25
Calhoun	8	8
Chickasaw	9	9
Coahoma	23	23
Desoto	0	35
Grenada	7	7
Itawamba	9	9
Lafayette	0	15
Lee	32	32
Marshall	0	16
Monroe	19	19
Panola	8	15
Pontotoc	13	13
Prentiss	5	15
Quitman	5	5
Sunflower	24	24
Tallahatchie	7	7
Tate	0	13
Tippah	0	12
Tishomingo	5	9
Tunica	0	6
Union	1	9
Yalobusha	2	5

Legend

School Functionality

Day 1

- Not Functional
- Functional
- US Routes
- Interstates
- Rivers
- Critical Counties

0 10 20 40 60

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
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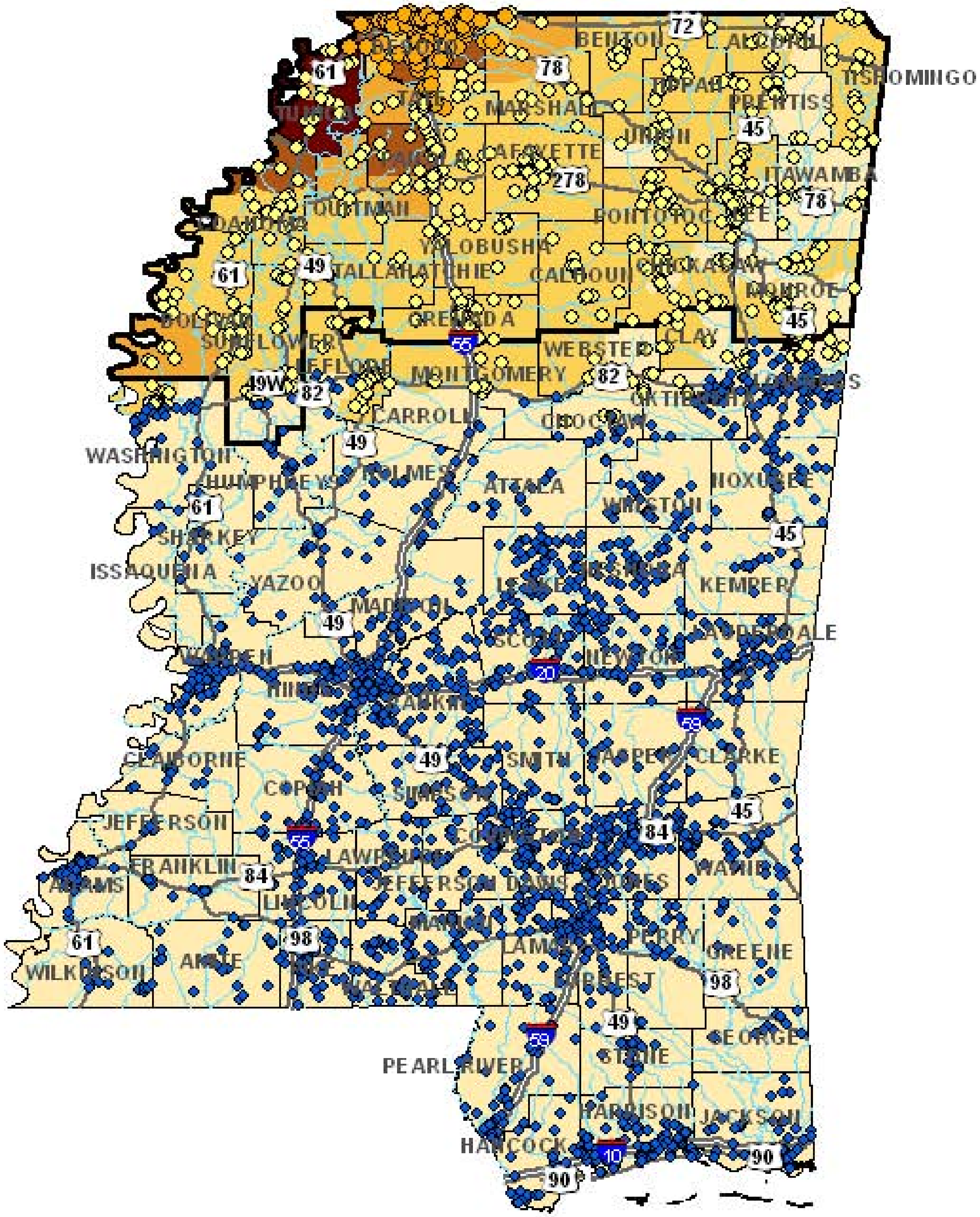
Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document,"GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Waste Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

April 2008



State of Mississippi Critical Counties (25)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Alcorn	21	0	0
Benton	8	0	0
Bolivar	37	0	0
Calhoun	13	0	0
Chickasaw	29	0	0
Coahoma	28	0	0
Desoto	90	89	0
Grenada	31	0	0
Itawamba	18	0	0
Lafayette	26	0	0
Lee	49	0	0
Marshall	24	5	0
Monroe	31	0	0
Panola	38	0	0
Pontotoc	25	0	0
Prentiss	13	0	0
Quitman	6	0	0
Sunflower	24	0	0
Tallahatchie	12	0	0
Tate	27	8	0
Tippah	17	0	0
Tishomingo	25	0	0
Tunica	16	0	0
Union	12	0	0
Yalobusha	10	0	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Waste Water Distribution Lines

No. of Leaks

- 0 - 5
- 6 - 25
- 26 - 50
- 51 - 150
- 151 - 265

US Routes
Interstates
Rivers
Critical Counties

0 10 20 40 60
Miles

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Mid-America Earthquake Center
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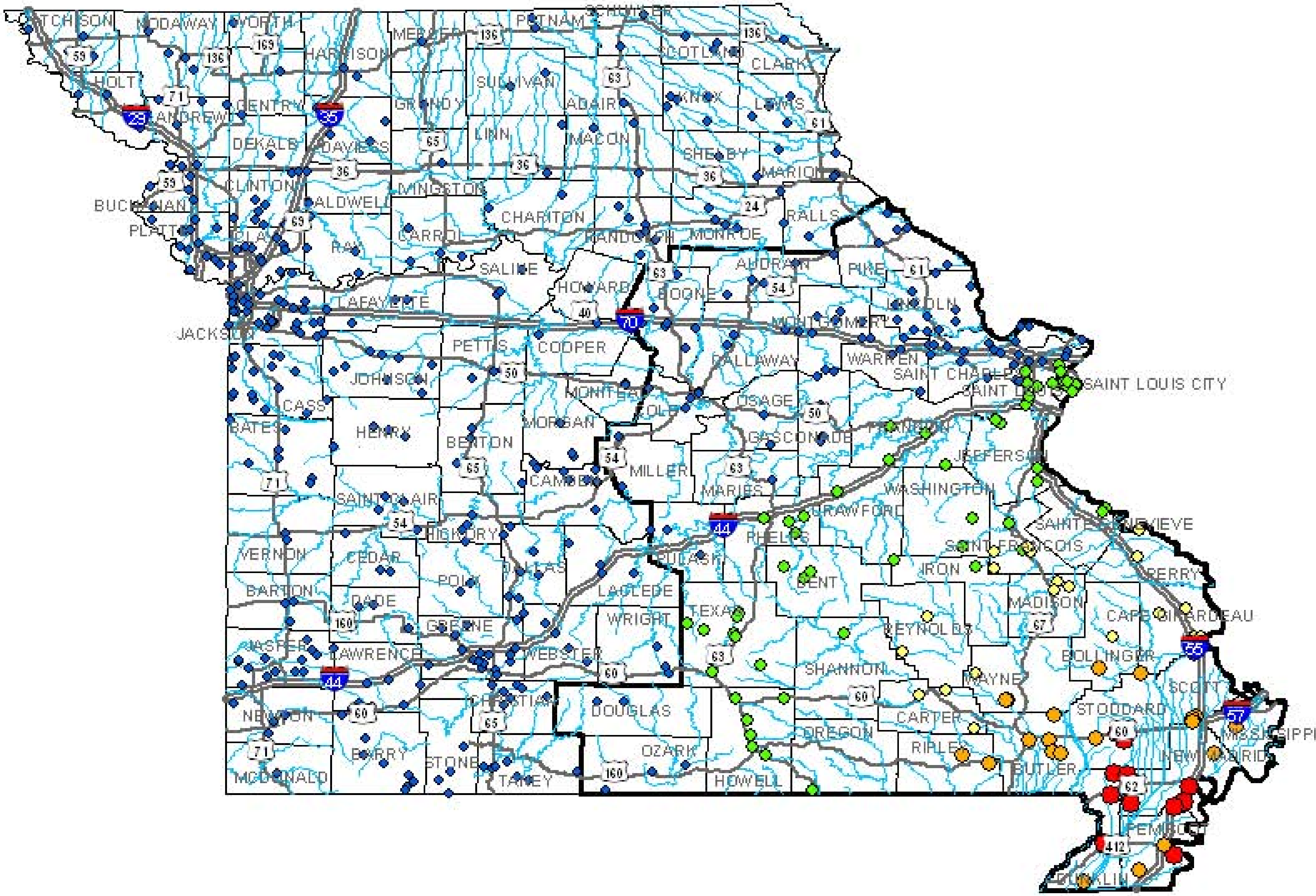
Theresa Jefferson, Principal Investigator

Airport Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	5	0	0
Bollinger	2	1	0
Boone	8	0	0
Butler	5	5	0
Callaway	5	0	0
Cape Girardeau	4	0	0
Carter	3	0	0
Cole	3	0	0
Crawford	1	0	0
Dent	3	0	0
Douglas	2	0	0
Dunklin	6	5	2
Franklin	4	0	0
Gasconade	7	0	0
Howell	6	0	0
Iron	2	0	0
Jefferson	5	0	0
Lincoln	12	0	0
Madison	3	0	0
Maries	1	0	0
Miller	2	0	0
Mississippi	1	1	0
Montgomery	7	0	0
New Madrid	7	7	2
Oregon	1	0	0
Osage	2	0	0
Ozark	3	0	0
Pemiscot	3	3	0
Perry	2	0	0
Phelps	4	0	0
Pike	5	0	0
Pulaski	3	0	0
Reynolds	2	0	0
Ripley	2	2	0
Saint Charles	14	0	0
Sainte Genevieve	2	0	0
Saint Francois	6	0	0
Saint Louis	18	0	0
Scott	3	3	0
Shannon	1	0	0
Stoddard	4	4	1
Texas	8	0	0
Warren	5	0	0
Washington	2	0	0
Wayne	3	2	0
Saint Louis (City)	12	0	0

Legend

Airport Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

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Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
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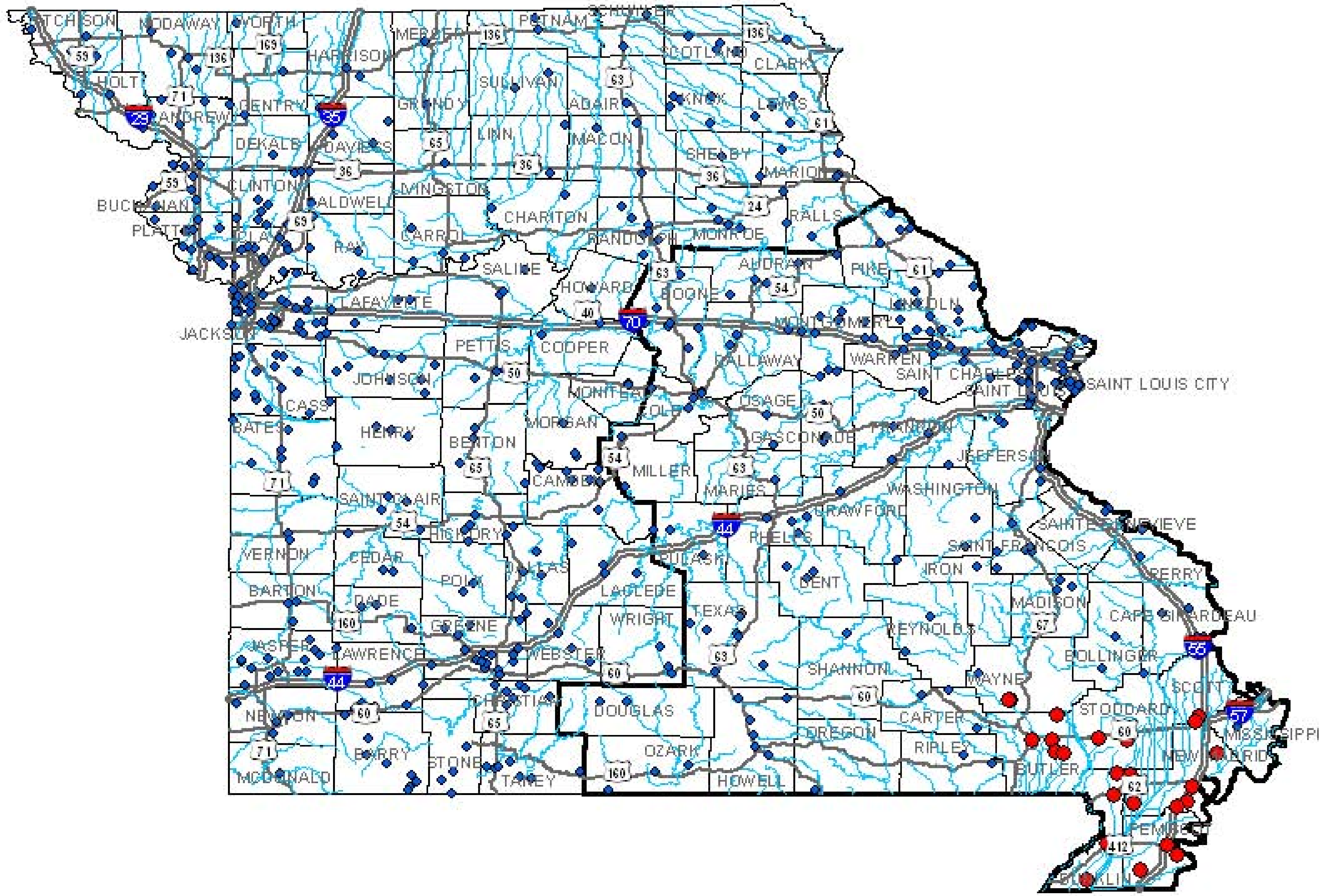
Theresa Jefferson, Principal Investigator

Airport Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Functional Facilities	Total No. of Facilities
Audrain	5	5
Bollinger	2	2
Boone	8	8
Butler	0	5
Callaway	5	5
Cape Girardeau	4	4
Carter	3	3
Cole	3	3
Crawford	1	1
Dent	3	3
Douglas	2	2
Dunklin	0	5
Franklin	4	4
Gasconade	7	7
Howell	6	6
Iron	2	2
Jefferson	5	5
Lincoln	12	12
Madison	3	3
Maries	1	1
Miller	2	2
Mississippi	1	1
Montgomery	7	7
New Madrid	0	7
Oregon	1	1
Osage	2	2
Ozark	3	3
Pemiscot	0	3
Perry	2	2
Phelps	4	4
Pike	5	5
Pulaski	3	3
Reynolds	2	2
Ripley	2	2
Saint Charles	14	14
Sainte Genevieve	2	2
Saint Francois	6	6
Saint Louis	18	18
Scott	2	3
Shannon	1	1
Stoddard	1	4
Texas	8	8
Warren	5	5
Washington	2	2
Wayne	1	3
Saint Louis (City)	12	12

Legend

Airport Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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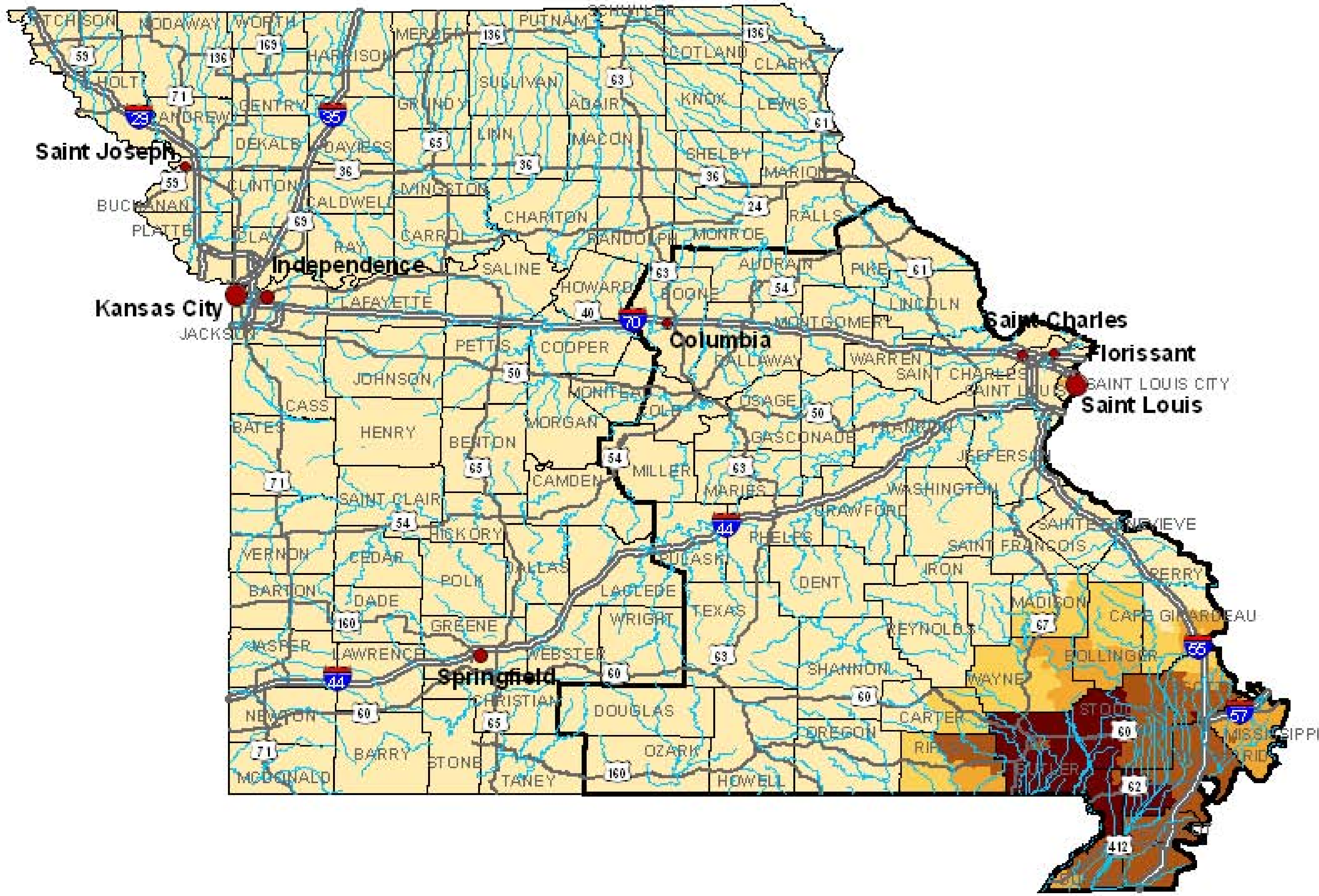
Worst Case Casualties - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Audrain	0	0	0
Bollinger	153	7	160
Boone	2	0	2
Butler	2,092	128	2,219
Callaway	1	0	1
Cape Girardeau	626	28	654
Carter	35	1	36
Cole	1	0	1
Crawford	0	0	0
Dent	0	0	0
Douglas	0	0	0
Dunklin	2,373	125	2,498
Franklin	2	0	2
Gasconade	0	0	0
Howell	1	0	1
Iron	3	0	3
Jefferson	88	2	90
Lincoln	1	0	1
Madison	15	1	16
Maries	0	0	0
Miller	0	0	0
Mississippi	408	18	427
Montgomery	0	0	0
New Madrid	1,168	69	1,237
Oregon	8	0	8
Osage	0	0	0
Ozark	0	0	0
Pemiscot	1,306	70	1,376
Perry	17	1	18
Phelps	1	0	1
Pike	0	0	0
Pulaski	1	0	1
Reynolds	9	0	9
Ripley	276	12	288
Saint Charles	3	0	3
Sainte Genevieve	5	0	5
Saint Francois	13	0	13
Saint Louis	274	8	283
Scott	1,391	69	1,460
Shannon	3	0	3
Stoddard	1,982	109	2,090
Texas	1	0	1
Warren	0	0	0
Washington	5	0	5
Wayne	197	8	205
Saint Louis (City)	2,502	118	2,620

Legend

Worst Case Casualties

2 AM

- 0 - 25
- 25 - 100
- 100 - 250
- 250 - 500
- 500 - 790

- Critical Counties
- Interstates
- US Routes
- Rivers

Major Cities

- 50,000 - 75,000
- 75,001 - 150,000
- 150,001 - 444,000

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

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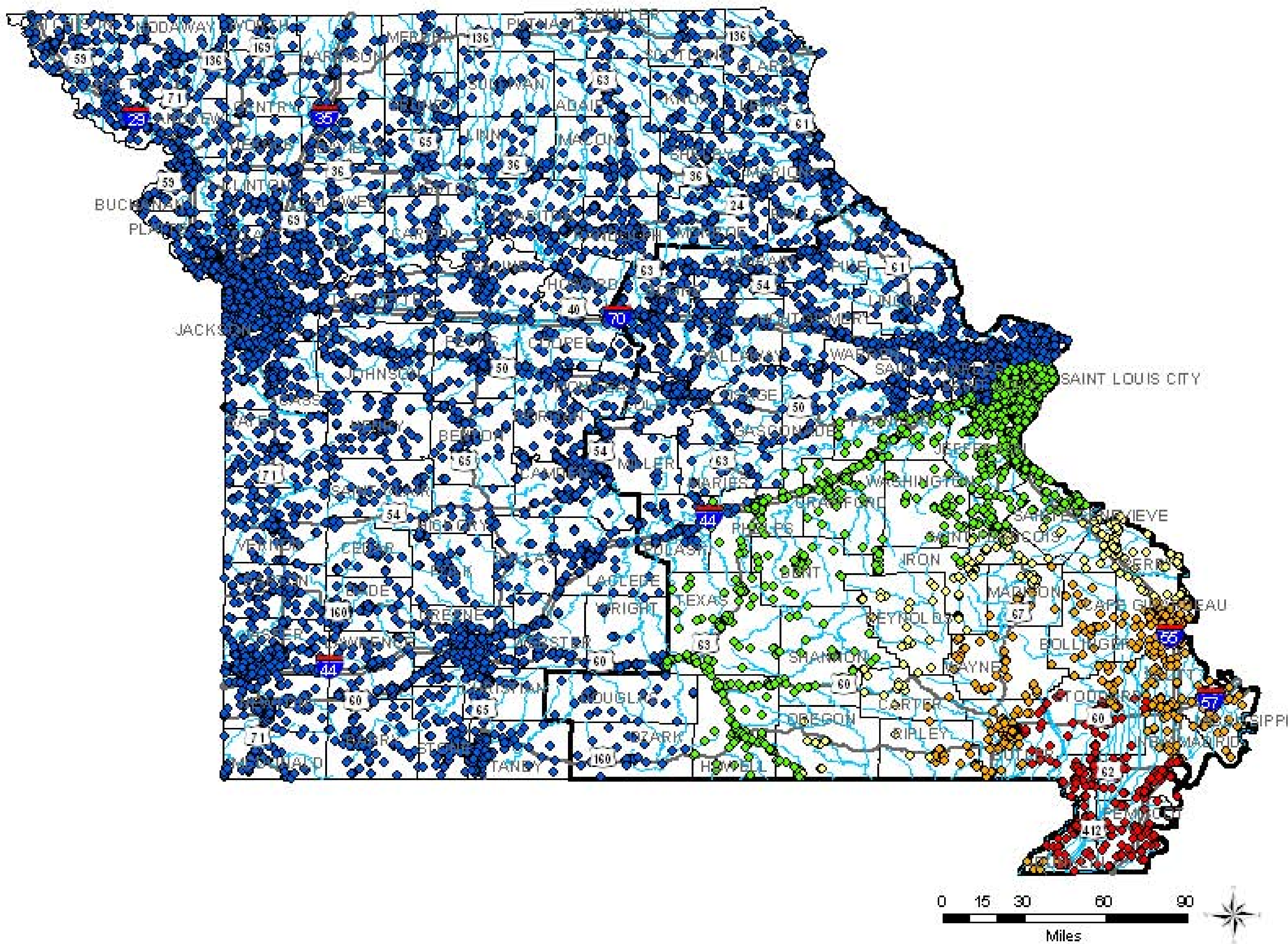
Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	208	0	0
Bollinger	81	81	0
Boone	468	0	0
Butler	189	189	0
Callaway	231	0	0
Cape Girardeau	325	294	0
Carter	40	5	0
Cole	284	0	0
Crawford	121	0	0
Dent	83	0	0
Douglas	48	0	0
Dunklin	180	180	49
Franklin	300	0	0
Gasconade	94	0	0
Howell	171	0	0
Iron	77	0	0
Jefferson	547	0	0
Lincoln	150	0	0
Madison	61	30	0
Maries	55	0	0
Miller	128	0	0
Mississippi	64	64	0
Montgomery	131	0	0
New Madrid	161	161	17
Oregon	55	0	0
Osage	100	0	0
Ozark	44	0	0
Pemiscot	128	128	34
Perry	111	0	0
Phelps	172	0	0
Pike	107	0	0
Pulaski	136	0	0
Reynolds	63	0	0
Ripley	64	60	0
Saint Charles	595	0	0
Sainte Genevieve	107	0	0
Saint Francois	198	0	0
Saint Louis	1814	0	0
Scott	187	187	0
Shannon	48	0	0
Stoddard	192	192	4
Texas	134	0	0
Warren	128	0	0
Washington	82	0	0
Wayne	85	85	0
Saint Louis (City)	758	0	0

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Interstates

US Routes

Rivers

Mid-America Earthquake Center

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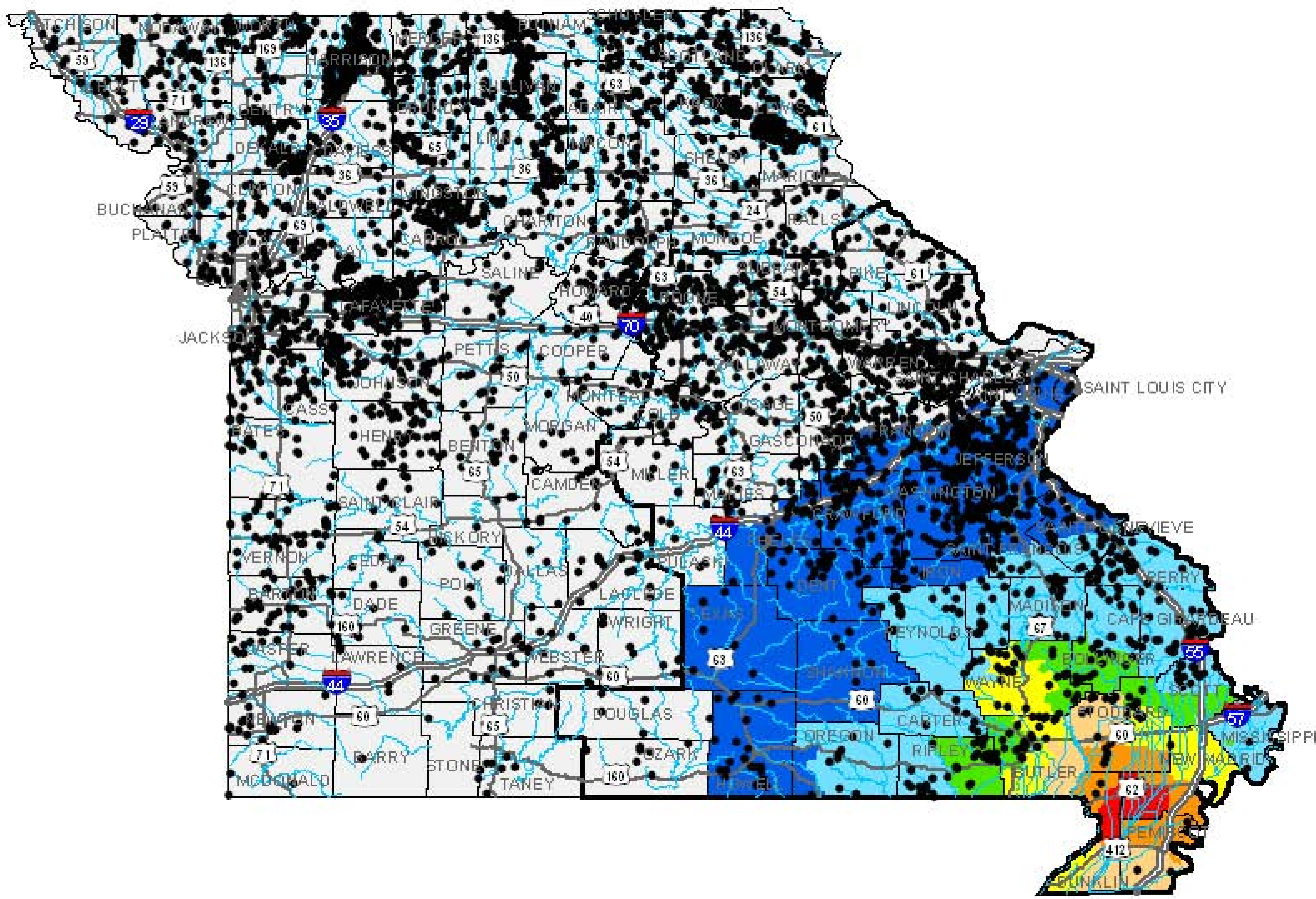
Dams - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Facilities
Audrain	87
Bollinger	32
Boone	129
Butler	28
Callaway	109
Cape Girardeau	30
Carter	13
Cole	33
Crawford	72
Dent	34
Douglas	5
Dunklin	2
Franklin	146
Gasconade	79
Howell	25
Iron	46
Jefferson	136
Lincoln	70
Madison	25
Maries	30
Miller	13
Mississippi	3
Montgomery	84
New Madrid	1
Oregon	10
Osage	21
Ozark	7
Pemiscot	3
Perry	36
Phelps	30
Pike	40
Pulaski	7
Reynolds	33
Ripley	39
Saint Charles	111
Sainte Genevieve	46
Saint Francois	59
Saint Louis	44
Scott	18
Shannon	8
Stoddard	34
Texas	7
Warren	113
Washington	114
Wayne	35
Saint Louis (City)	2

Legend

- Dams
- Critical Counties
- Interstates
- US Routes
- Rivers

MMI

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

0 15 30 60 90
Miles

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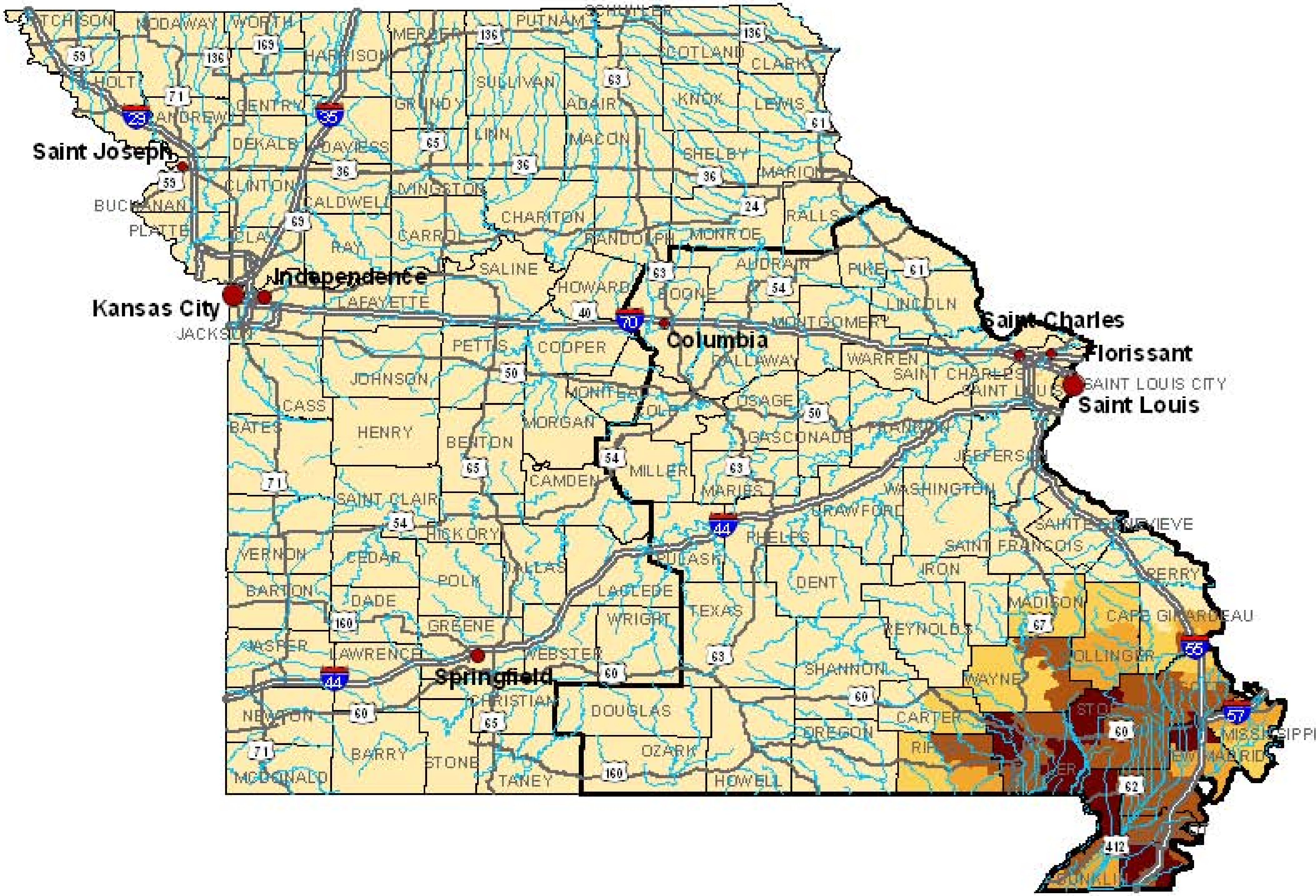
Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Debris - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Brick/Wood (Tons)	Steel/Concrete (Tons)	Total Debris (Tons)
Audrain	1,000	0	1,000
Bollinger	39,000	34,000	73,000
Boone	3,000	0	3,000
Butler	418,000	554,000	971,000
Callaway	1,000	0	1,000
Cape Girardeau	207,000	218,000	425,000
Carter	12,000	9,000	22,000
Cole	1,000	0	2,000
Crawford	0	0	1,000
Dent	0	0	0
Douglas	0	0	0
Dunklin	397,000	444,000	841,000
Franklin	2,000	0	2,000
Gasconade	0	0	0
Howell	1,000	0	1,000
Iron	3,000	1,000	4,000
Jefferson	43,000	18,000	61,000
Lincoln	1,000	0	1,000
Madison	6,000	3,000	9,000
Maries	0	0	0
Miller	0	0	1,000
Mississippi	77,000	73,000	151,000
Montgomery	0	0	0
New Madrid	218,000	246,000	464,000
Oregon	3,000	1,000	4,000
Osage	0	0	0
Ozark	0	0	0
Pemiscot	235,000	290,000	525,000
Perry	9,000	5,000	14,000
Phelps	1,000	0	1,000
Pike	0	0	0
Pulaski	1,000	0	1,000
Reynolds	4,000	2,000	6,000
Ripley	70,000	74,000	145,000
Saint Charles	5,000	0	5,000
Sainte Genevieve	6,000	2,000	8,000
Saint Francois	12,000	4,000	17,000
Saint Louis	184,000	79,000	263,000
Scott	285,000	335,000	620,000
Shannon	2,000	1,000	3,000
Stoddard	344,000	377,000	721,000
Texas	0	0	1,000
Warren	0	0	1,000
Washington	4,000	1,000	5,000
Wayne	63,000	51,000	114,000
Saint Louis (City)	513,000	564,000	1,077,000

Legend

Total Debris

Thousands of Tons

- 0 - 5
- 5 - 25
- 25 - 50
- 50 - 100
- 100 - 270

Major Cities

- 50,000 - 75,000
- 75,001 - 150,000
- 150,001 - 444,000

Critical Counties

Interstates

US Routes

Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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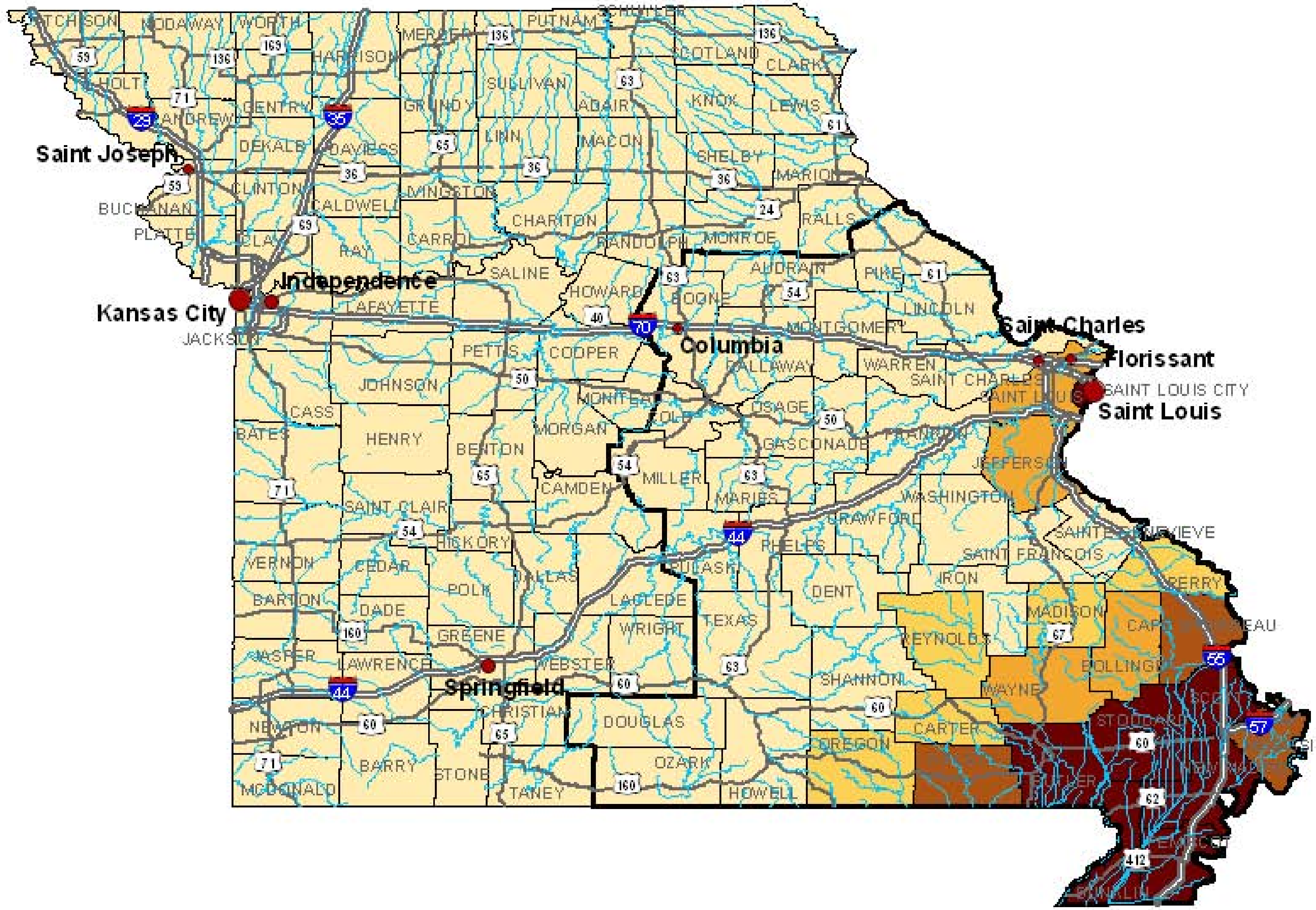
Displaced Population - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Displaced Residences	Estimate of Displaced Population
Audrain	0	0
Bollinger	481	1213
Boone	0	1
Butler	6,184	15115
Callaway	0	0
Cape Girardeau	1,702	4812
Carter	94	236
Cole	0	0
Crawford	0	0
Dent	0	0
Douglas	0	0
Dunklin	8,322	20674
Franklin	0	0
Gasconade	0	0
Howell	0	0
Iron	0	1
Jefferson	226	625
Lincoln	0	0
Madison	48	120
Maries	0	0
Miller	0	0
Mississippi	1,484	3851
Montgomery	0	0
New Madrid	4,095	10341
Oregon	22	54
Osage	0	0
Ozark	0	0
Pemiscot	4,275	10911
Perry	47	123
Phelps	0	0
Pike	0	0
Pulaski	0	0
Reynolds	24	61
Ripley	875	2182
Saint Charles	0	0
Sainte Genevieve	0	1
Saint Francois	2	6
Saint Louis	743	1868
Scott	4,338	11221
Shannon	0	0
Stoddard	6,590	16226
Texas	0	0
Warren	0	0
Washington	0	1
Wayne	718	1714
Saint Louis (City)	8,922	21123

Legend

Displaced Population

- 0 - 50
- 51 - 500
- 501 - 2,000
- 2,001 - 10,000
- 10,001 - 21,100

- Rivers
- US Routes
- Interstates
- Critical Counties

Major Cities

- 50,000 - 75,000
- 75,001 - 150,000
- 150,001 - 444,000

0 15 30 60 90

Miles

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Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
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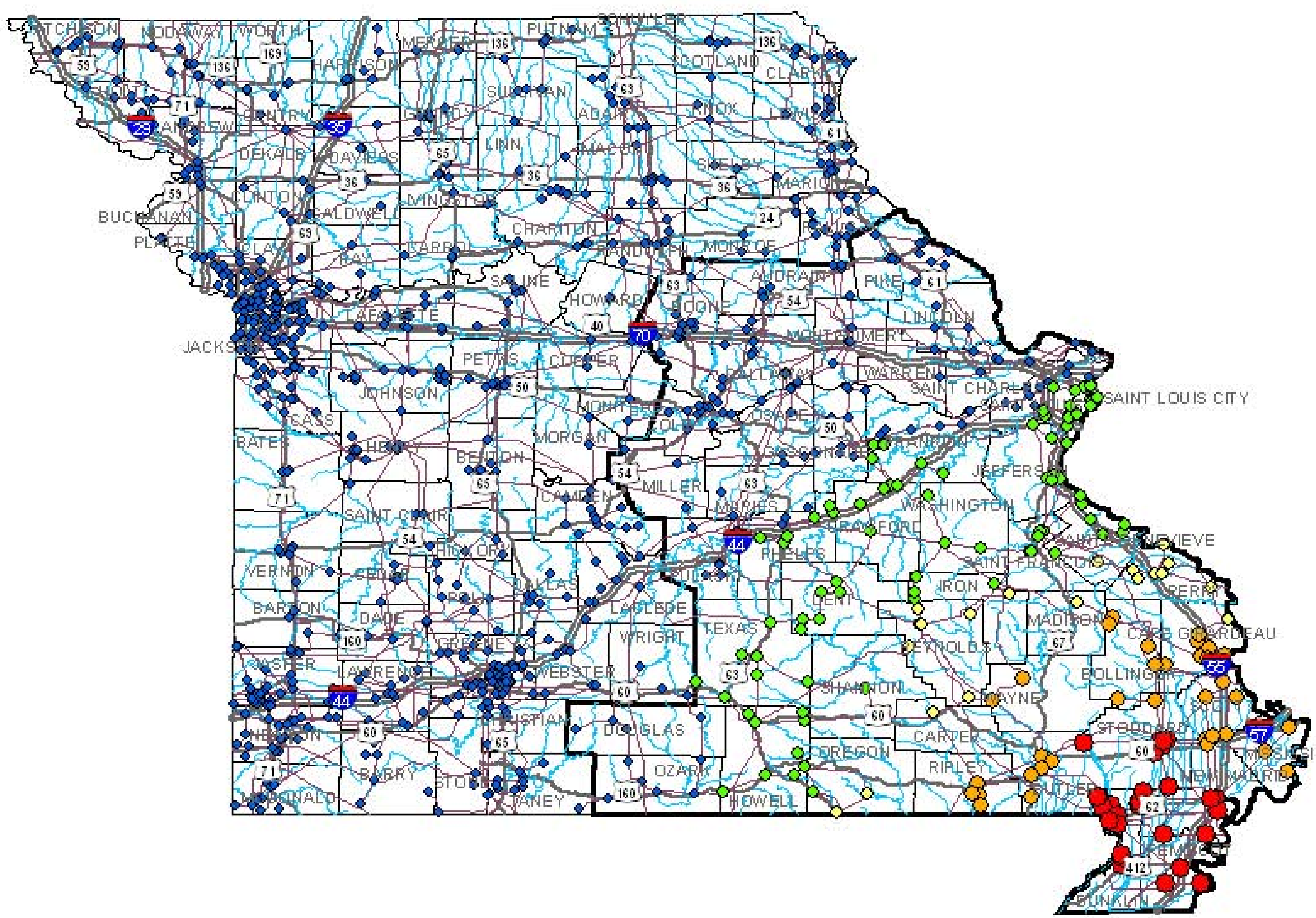
Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	23	0	0
Bollinger	5	5	0
Boone	21	0	0
Butler	8	8	0
Callaway	10	0	0
Cape Girardeau	19	19	0
Carter	1	0	0
Cole	18	0	0
Crawford	5	0	0
Dent	0	0	0
Douglas	4	0	0
Dunklin	23	23	4
Franklin	12	0	0
Gasconade	21	0	0
Howell	9	0	0
Iron	5	0	0
Jefferson	7	0	0
Lincoln	5	0	0
Madison	1	0	0
Maries	4	0	0
Miller	13	0	0
Mississippi	4	4	0
Montgomery	8	0	0
New Madrid	7	7	2
Oregon	5	0	0
Osage	7	0	0
Ozark	6	0	0
Pemiscot	4	4	1
Perry	3	0	0
Phelps	8	0	0
Pike	17	0	0
Pulaski	8	0	0
Reynolds	3	0	0
Ripley	4	4	0
Saint Charles	11	0	0
Sainte Genevieve	7	0	0
Saint Francois	5	0	0
Saint Louis	29	0	0
Scott	11	11	0
Shannon	2	0	0
Stoddard	10	10	0
Texas	3	0	0
Warren	1	0	0
Washington	3	0	0
Wayne	2	2	0
Saint Louis (City)	25	0	0

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Transmission Lines
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

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Mid-America Earthquake Center

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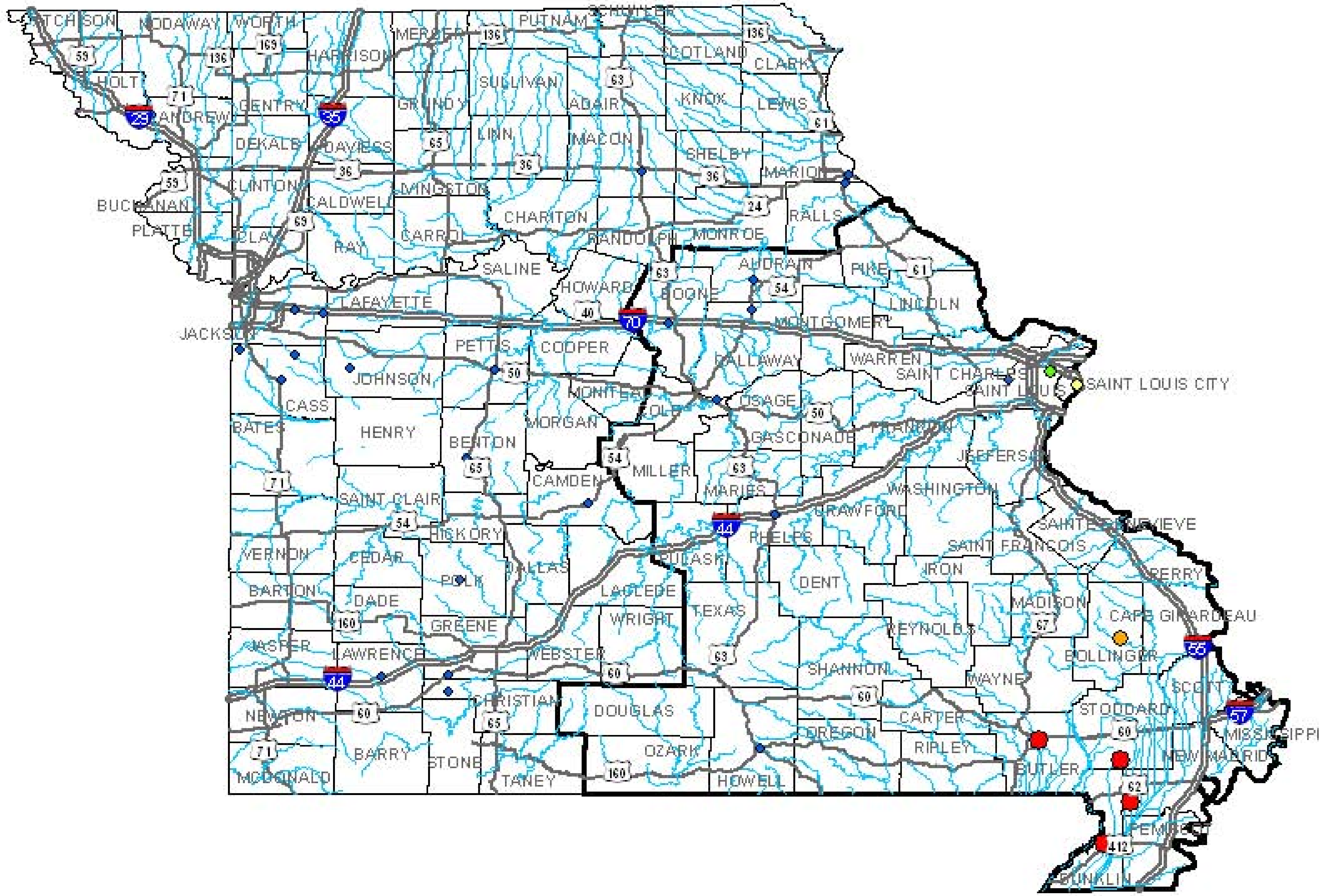
Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	1	0	0
Bollinger	1	1	0
Boone	1	0	0
Butler	1	1	1
Callaway	1	0	0
Cape Girardeau	0	0	0
Carter	0	0	0
Cole	1	0	0
Crawford	0	0	0
Dent	0	0	0
Douglas	0	0	0
Dunklin	1	1	1
Franklin	0	0	0
Gasconade	0	0	0
Howell	1	0	0
Iron	0	0	0
Jefferson	0	0	0
Lincoln	0	0	0
Madison	0	0	0
Maries	0	0	0
Miller	1	0	0
Mississippi	2	2	0
Montgomery	0	0	0
New Madrid	1	1	1
Oregon	0	0	0
Osage	0	0	0
Ozark	0	0	0
Pemiscot	0	0	0
Perry	0	0	0
Phelps	1	0	0
Pike	0	0	0
Pulaski	0	0	0
Reynolds	0	0	0
Ripley	0	0	0
Saint Charles	0	0	0
Saint Francois	0	0	0
Saint Louis	2	0	0
Saint Louis (City)	1	0	0
Sainte Genevieve	0	0	0
Scott	0	0	0
Shannon	0	0	0
Stoddard	1	1	1
Texas	0	0	0
Warren	0	0	0
Washington	0	0	0
Wayne	0	0	0

Legend

Emergency Operation Centers

At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Interstates

US Routes

Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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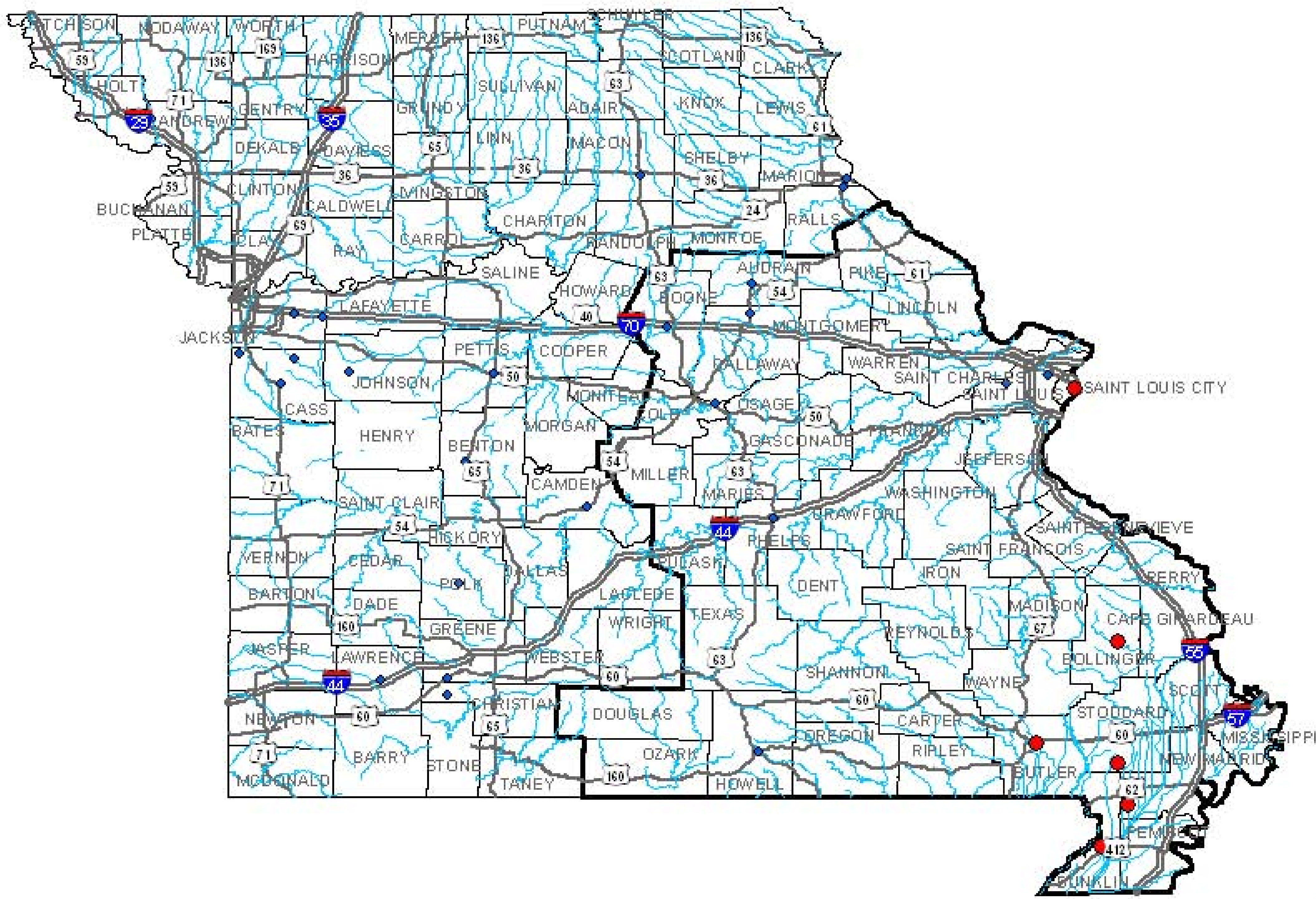
EOC Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Functional Facilities	Total No. of Facilities
Audrain	1	1
Bollinger	0	1
Boone	1	1
Butler	0	1
Callaway	1	1
Cole	1	1
Dunklin	0	1
Howell	1	1
Miller	1	1
Mississippi	0	2
New Madrid	0	1
Phelps	1	1
Saint Louis	2	2
Stoddard	0	1
Saint Louis (City)	1	1
Cape Girardeau	0	0
Carter	0	0
Crawford	0	0
Dent	0	0
Douglas	0	0
Franklin	0	0
Gasconade	0	0
Iron	0	0
Jefferson	0	0
Lincoln	0	0
Madison	0	0
Maries	0	0
Montgomery	0	0
Oregon	0	0
Osage	0	0
Ozark	0	0
Pemiscot	0	0
Perry	0	0
Pike	0	0
Pulaski	0	0
Reynolds	0	0
Ripley	0	0
Saint Charles	0	0
Sainte Genevieve	0	0
Saint Francois	0	0
Scott	0	0
Shannon	0	0
Texas	0	0
Warren	0	0
Washington	0	0
Wayne	0	0

Legend

Emergency Operation Centers

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

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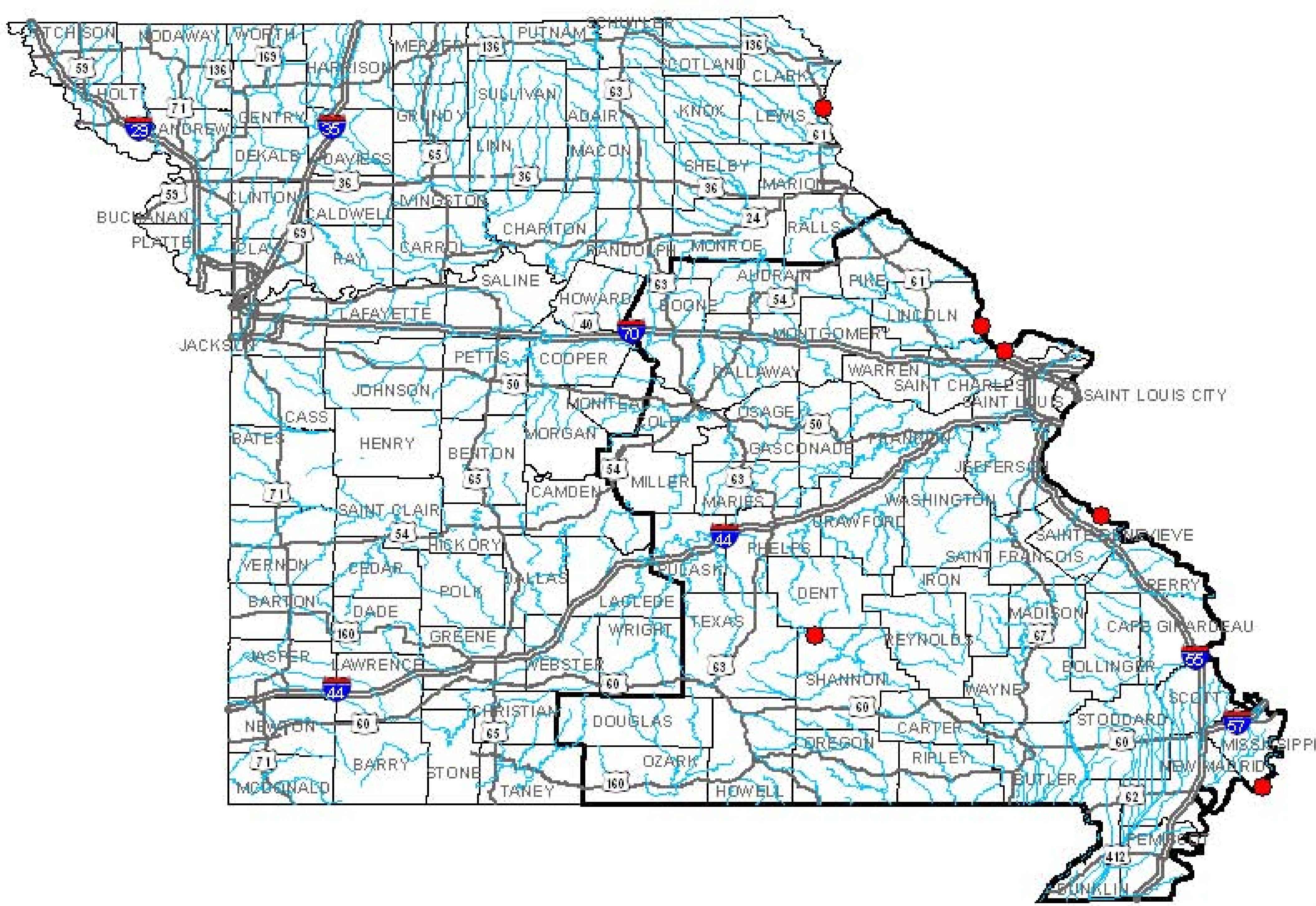
Ferry Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	0	0	0
Bollinger	0	0	0
Boone	0	0	0
Butler	0	0	0
Callaway	0	0	0
Cape Girardeau	0	0	0
Carter	0	0	0
Cole	0	0	0
Crawford	0	0	0
Dent	0	0	0
Douglas	0	0	0
Dunklin	0	0	0
Franklin	0	0	0
Gasconade	0	0	0
Howell	0	0	0
Iron	0	0	0
Jefferson	0	0	0
Lincoln	1	1	1
Madison	0	0	0
Maries	0	0	0
Miller	0	0	0
Mississippi	2	2	2
Montgomery	0	0	0
New Madrid	0	0	0
Oregon	0	0	0
Osage	0	0	0
Ozark	0	0	0
Pemiscot	0	0	0
Perry	0	0	0
Phelps	0	0	0
Pike	0	0	0
Pulaski	0	0	0
Reynolds	0	0	0
Ripley	0	0	0
Saint Charles	1	1	1
Saint Francois	0	0	0
Saint Louis	0	0	0
Saint Louis (City)	0	0	0
Sainte Genevieve	1	1	1
Scott	0	0	0
Shannon	2	2	2
Stoddard	0	0	0
Texas	0	0	0
Warren	0	0	0
Washington	0	0	0
Wayne	0	0	0

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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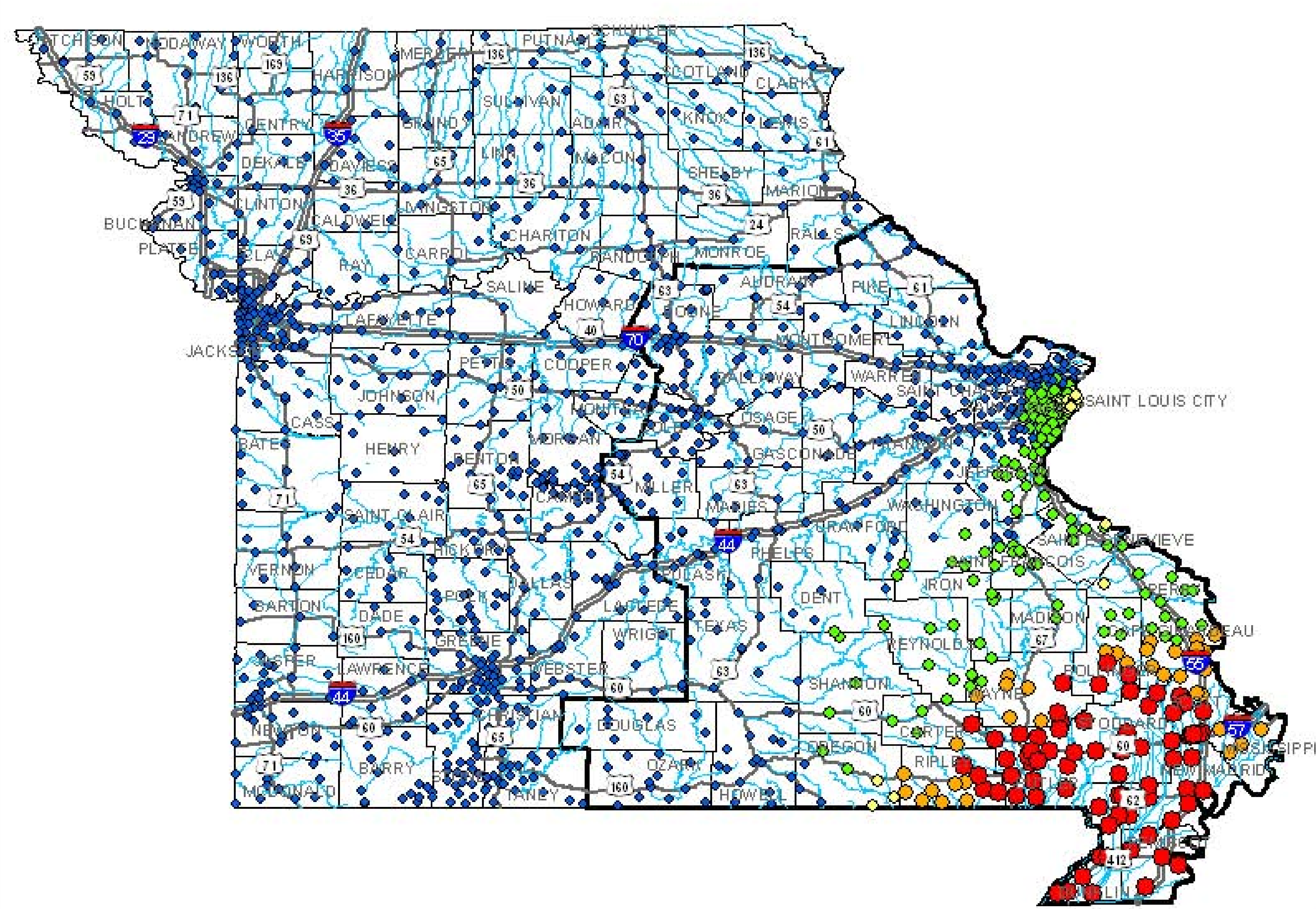
Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	7	0	0
Bollinger	10	6	0
Boone	27	0	0
Butler	19	19	19
Callaway	19	0	0
Cape Girardeau	18	11	0
Carter	7	4	0
Cole	19	0	0
Crawford	10	0	0
Dent	5	0	0
Douglas	9	0	0
Dunklin	12	12	12
Franklin	26	0	0
Gasconade	11	0	0
Howell	19	0	0
Iron	7	0	0
Jefferson	32	0	0
Lincoln	10	0	0
Madison	3	0	0
Maries	5	0	0
Miller	19	0	0
Mississippi	5	5	0
Montgomery	8	0	0
New Madrid	10	10	5
Oregon	8	0	0
Osage	7	0	0
Ozark	14	0	0
Pemiscot	5	5	5
Perry	8	0	0
Phelps	9	0	0
Pike	8	0	0
Pulaski	12	0	0
Reynolds	7	0	0
Ripley	12	12	0
Saint Charles	33	0	0
Sainte Genevieve	9	0	0
Saint Francois	18	0	0
Saint Louis	85	0	0
Scott	14	14	0
Shannon	5	0	0
Stoddard	9	9	7
Texas	12	0	0
Warren	10	0	0
Washington	11	0	0
Wayne	12	9	0
Saint Louis (City)	27	0	0

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Interstates

US Routes

Rivers

0 15 30 60 90

Miles

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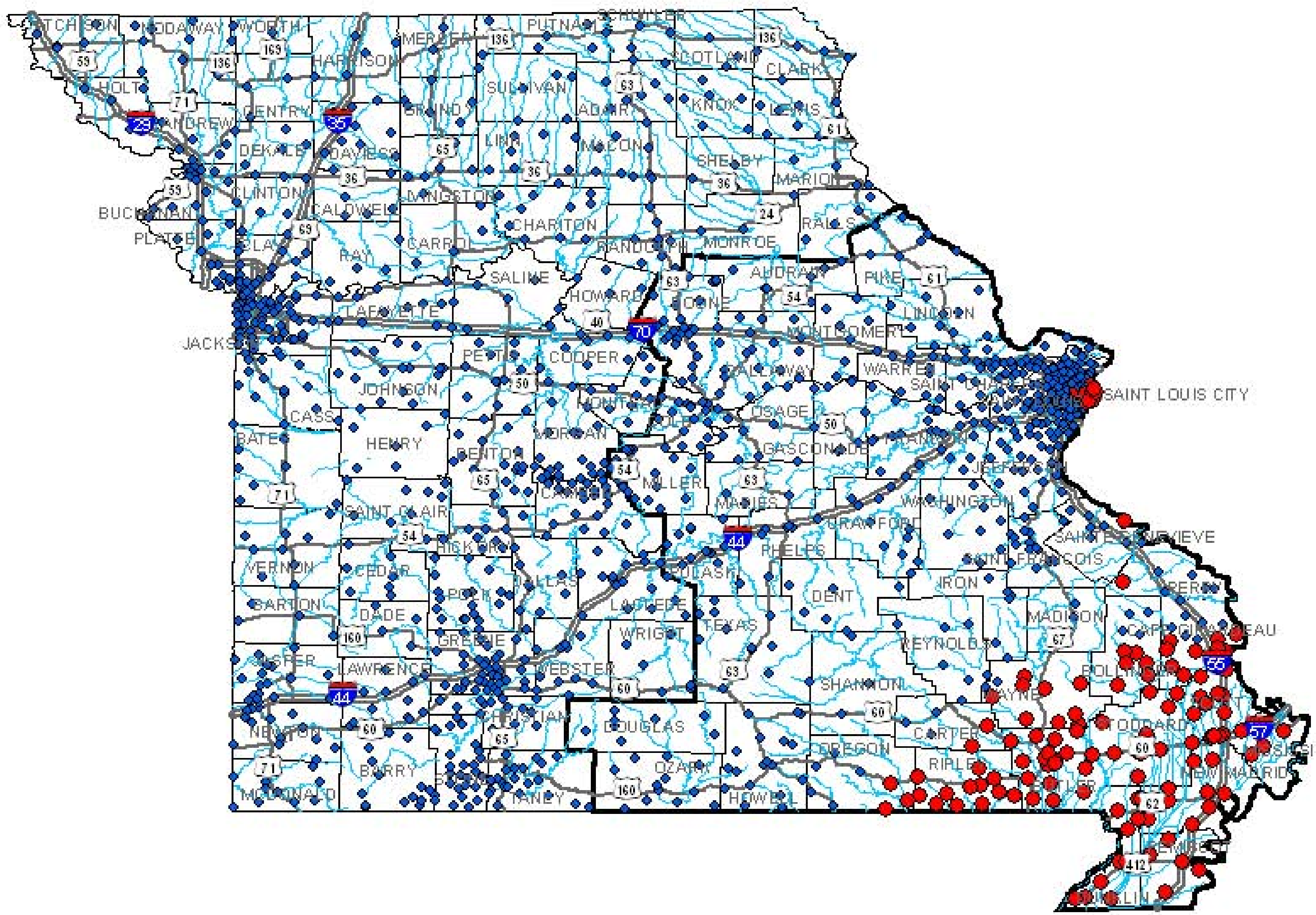
Fire Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

Audrain	7	7
Bollinger	4	10
Boone	27	27
Butler	0	19
Callaway	19	19
Cape Girardeau	7	18
Carter	3	7
Cole	19	19
Crawford	10	10
Dent	5	5
Douglas	9	9
Dunklin	0	12
Franklin	26	26
Gasconade	11	11
Howell	18	18
Iron	7	7
Jefferson	32	32
Lincoln	10	10
Madison	3	3
Maries	5	5
Miller	19	19
Mississippi	0	5
Montgomery	8	8
New Madrid	0	10
Oregon	5	8
Osage	7	7
Ozark	14	14
Pemiscot	0	5
Perry	5	6
Phelps	9	9
Pike	8	8
Pulaski	12	12
Reynolds	7	7
Ripley	0	12
Saint Charles	33	33
Sainte Genevieve	8	9
Saint Francois	16	16
Saint Louis	84	85
Scott	0	14
Shannon	5	5
Stoddard	0	9
Texas	12	12
Warren	10	10
Washington	11	11
Wayne	3	12
Saint Louis(City)	14	27

Legend

Fire Station Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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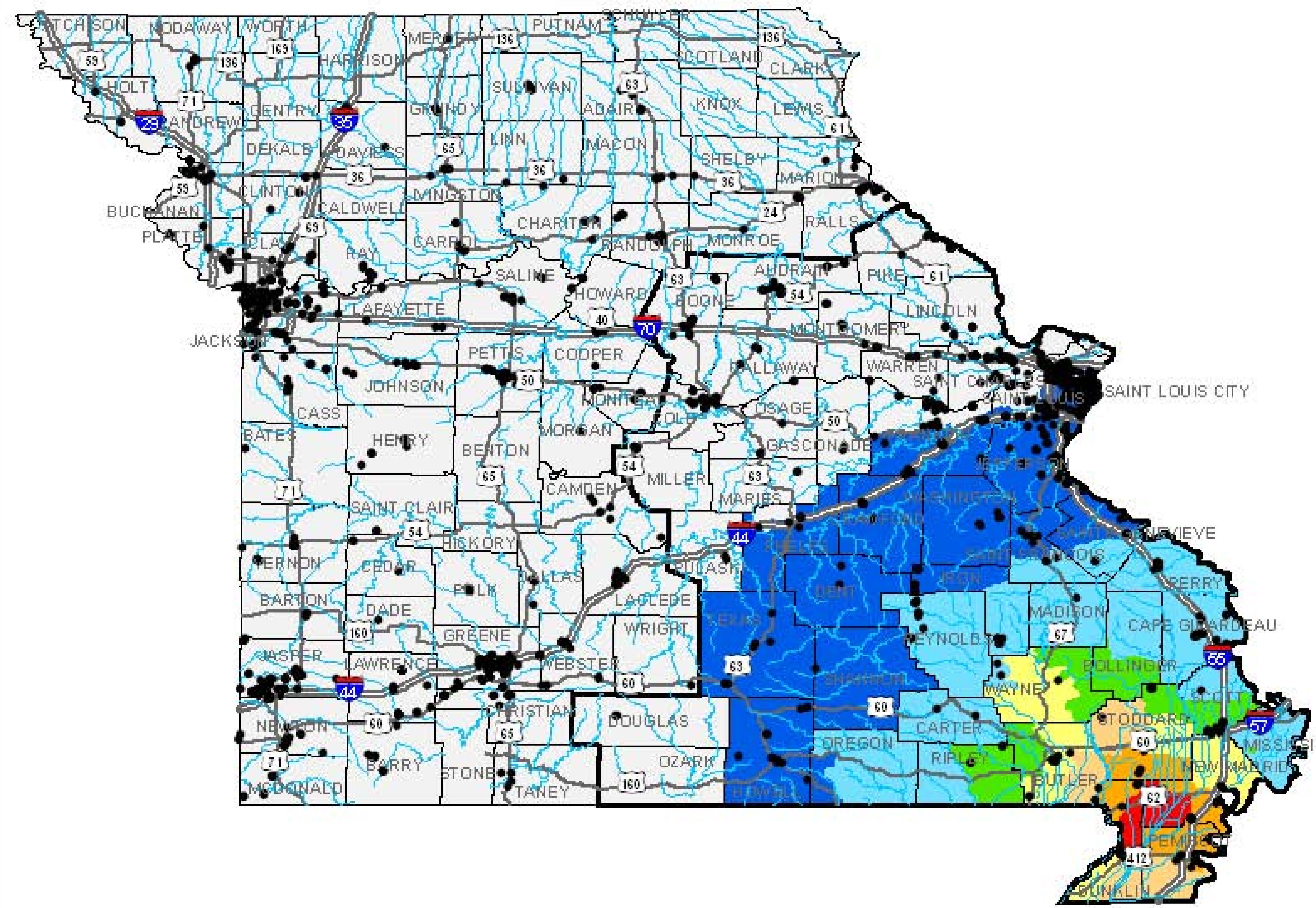
Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Facilities
Audrain	36
Bollinger	0
Boone	29
Butler	21
Callaway	11
Cape Girardeau	56
Carter	2
Cole	27
Crawford	12
Dent	2
Douglas	2
Dunklin	21
Franklin	91
Gasconade	2
Howell	17
Iron	22
Jefferson	96
Lincoln	9
Madison	1
Maries	3
Miller	4
Mississippi	2
Montgomery	12
New Madrid	28
Oregon	0
Osage	8
Ozark	0
Pemiscot	11
Perry	8
Phelps	9
Pike	49
Pulaski	2
Reynolds	15
Ripley	5
Saint Charles	103
Saint Francois	9
Saint Louis	370
Saint Louis(City)	353
Sainte Genevieve	11
Scott	22
Shannon	1
Stoddard	17
Texas	8
Warren	19
Washington	22
Wayne	3

Legend

- Hazmat Facilities
- Critical Counties
- Interstates
- US Routes
- Rivers

MMI

- XII
- XI
- X
- IX
- VIII
- VII
- VI
- < VI

0 15 30 60 90
Miles

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Mid-America Earthquake Center
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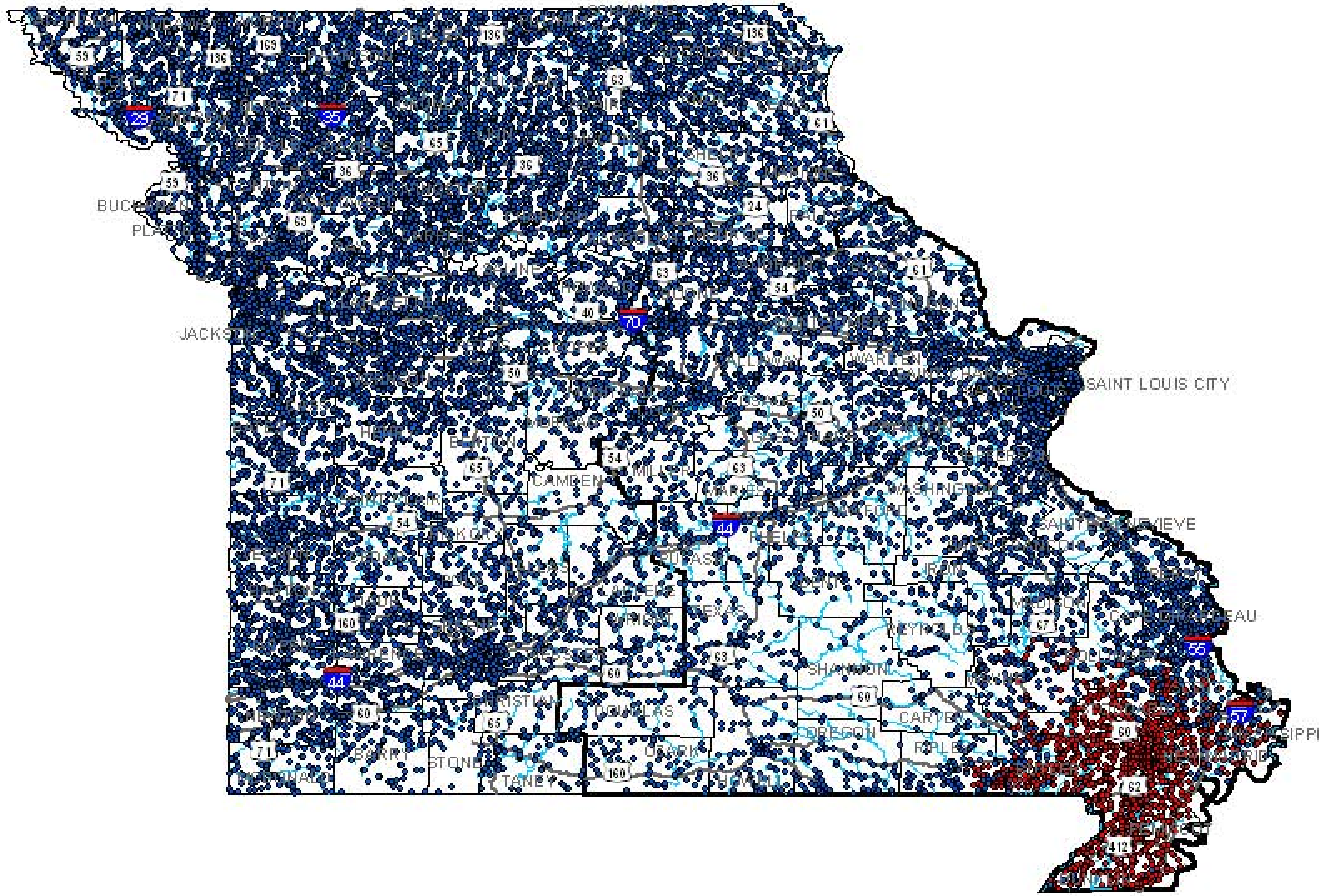
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Highway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Functional Facilities	Total No. of Facilities
Audrain	287	287
Bollinger	98	117
Boone	256	256
Butler	70	251
Callaway	273	273
Cape Girardeau	311	323
Carter	30	30
Cole	154	154
Crawford	101	101
Dent	73	73
Douglas	67	67
Dunklin	7	206
Franklin	273	273
Gasconade	127	127
Howell	145	145
Iron	105	105
Jefferson	330	330
Lincoln	161	161
Madison	102	102
Maries	64	64
Miller	113	113
Mississippi	57	91
Montgomery	162	162
New Madrid	44	274
Oregon	78	78
Osage	83	83
Ozark	81	81
Pemiscot	3	192
Perry	118	118
Phelps	117	117
Pike	181	181
Pulaski	74	74
Reynolds	72	72
Ripley	88	114
Saint Charles	216	216
Sainte Genevieve	78	78
Saint Francois	144	144
Saint Louis	705	705
Scott	113	172
Shannon	50	50
Stoddard	42	412
Texas	148	148
Warren	110	110
Washington	148	148
Wayne	157	158
Saint Louis (City)	240	240

Legend

Highway Bridge Functionality

Day 1

- Not Functional
- Functional

Critical Counties

Interstates

US Routes

Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

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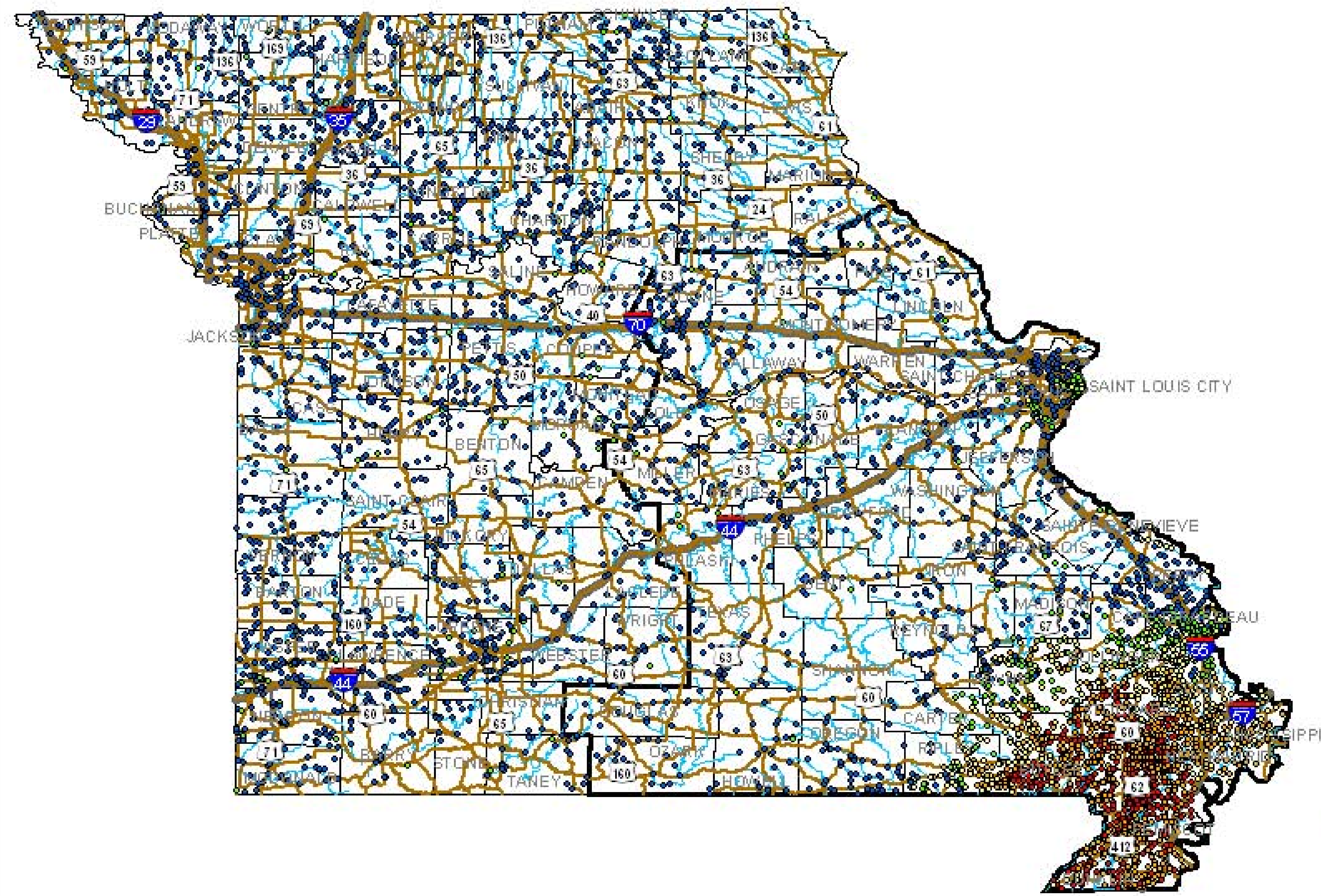
Highway Bridge Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	287	0	0
Bollinger	117	20	1
Boone	256	0	0
Butler	251	184	92
Callaway	273	0	0
Cape Girardeau	323	12	0
Carter	30	0	0
Cole	154	0	0
Crawford	101	0	0
Dent	73	0	0
Douglas	67	0	0
Dunklin	208	158	147
Franklin	273	0	0
Gasconade	127	0	0
Howell	145	0	0
Iron	105	0	0
Jefferson	330	0	0
Lincoln	161	0	0
Madison	102	0	0
Maries	64	0	0
Miller	113	0	0
Mississippi	91	34	0
Montgomery	182	0	0
New Madrid	274	235	182
Oregon	76	0	0
Osage	83	0	0
Ozark	81	0	0
Pemiscot	192	180	88
Perry	118	0	0
Phelps	117	0	0
Pike	181	0	0
Pulaski	74	0	0
Reynolds	72	0	0
Ripley	114	30	4
Saint Charles	218	0	0
Sainte Genevieve	79	0	0
Saint Francois	144	0	0
Saint Louis	705	0	0
Scott	172	59	6
Shannon	60	0	0
Stoddard	412	370	151
Texas	148	0	0
Warren	110	0	0
Washington	148	0	0
Wayne	188	31	0
Saint Louis (City)	240	0	0

Legend
Highway Bridge Damage
At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Highway Segments
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90
Miles

Mid-America Earthquake Center

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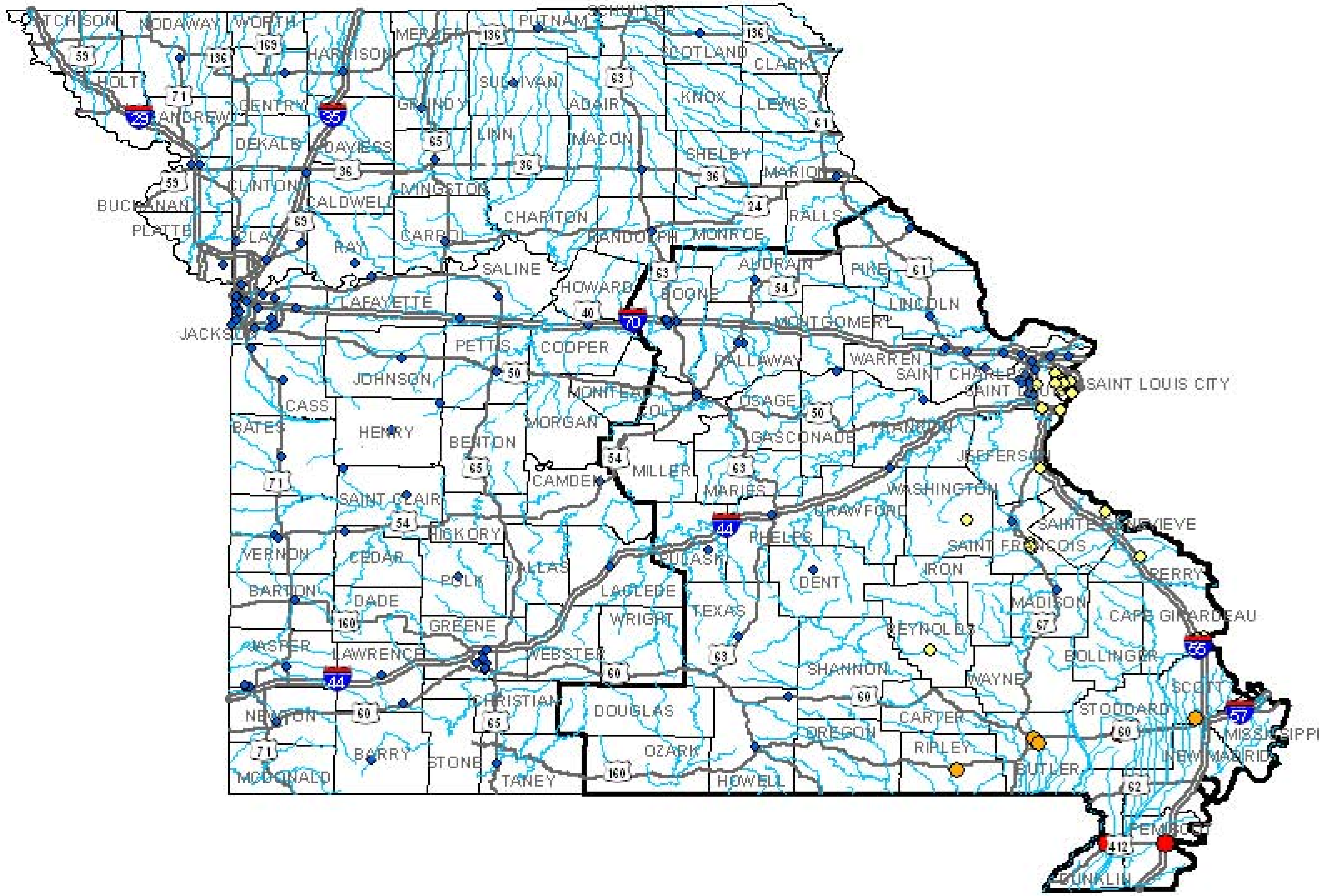
Hospital Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	1	0	0
Boone	7	0	0
Butler	3	3	0
Callaway	2	0	0
Cape Girardeau	2	0	0
Cole	2	0	0
Crawford	1	0	0
Dent	1	0	0
Dunklin	1	1	1
Franklin	1	0	0
Gasconade	1	0	0
Howell	2	0	0
Jefferson	1	0	0
Lincoln	1	0	0
Madison	1	0	0
Pemiscot	1	1	1
Perry	1	0	0
Phelps	1	0	0
Pike	1	0	0
Pulaski	1	0	0
Reynolds	1	0	0
Ripley	1	1	0
Saint Charles	6	0	0
Sainte Genevieve	1	0	0
Saint Francois	4	0	0
Saint Louis	18	0	0
Scott	1	1	0
Stoddard	1	1	1
Texas	1	0	0
Washington	1	0	0
Saint Louis (City)	13	0	0
Bollinger	0	0	0
Carter	0	0	0
Douglas	0	0	0
Iron	0	0	0
Maries	0	0	0
Miller	0	0	0
Mississippi	0	0	0
Montgomery	0	0	0
New Madrid	0	0	0
Oregon	0	0	0
Osage	0	0	0
Ozark	0	0	0
Shannon	0	0	0
Warren	0	0	0
Wayne	0	0	0

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Interstates

US Routes

Rivers

0 15 30 60 90

Miles

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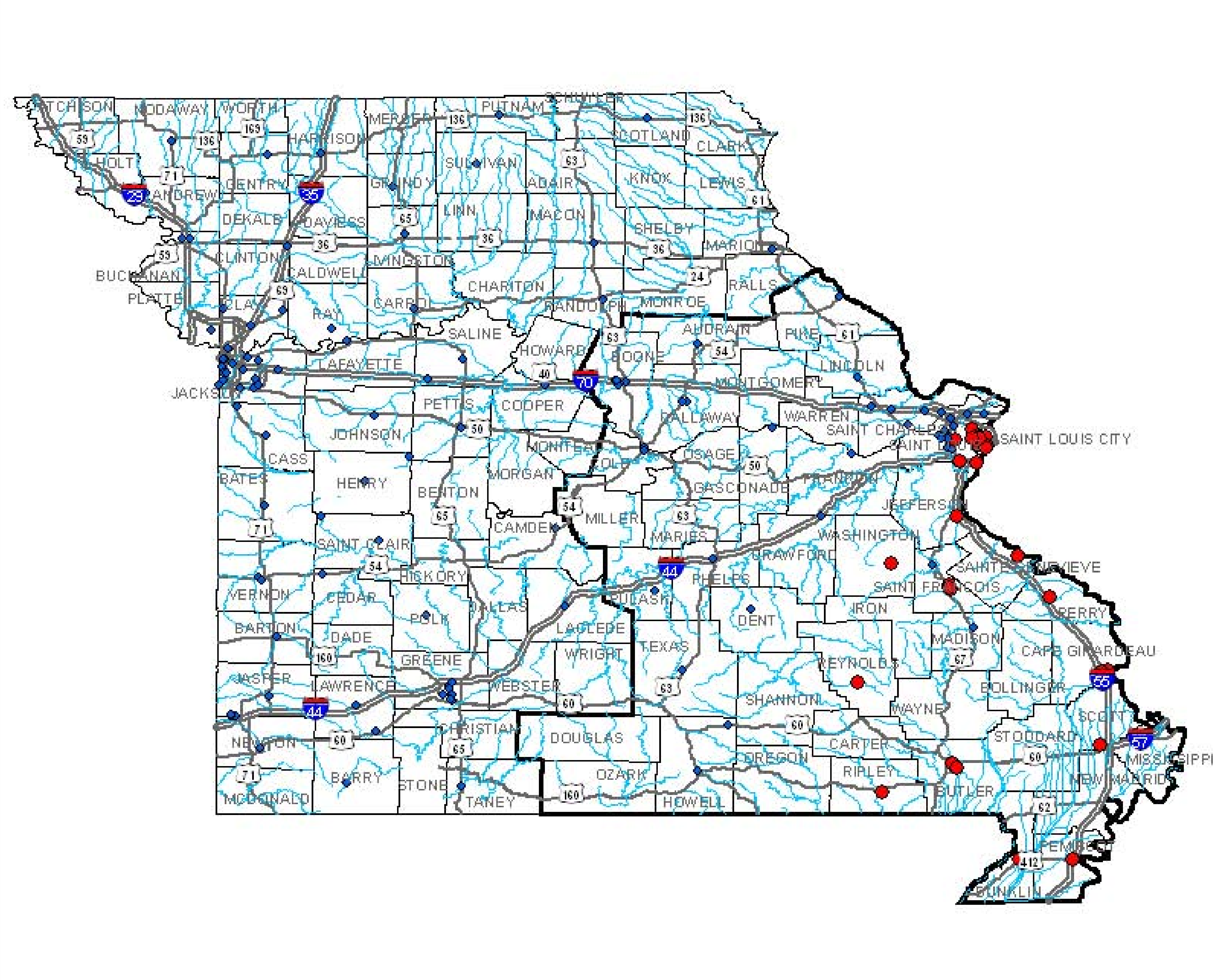
Hospital Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Functional Facilities	Total No. of Facilities
Audrain	1	1
Boone	7	7
Butler	0	3
Callaway	2	2
Cape Girardeau	0	2
Cole	2	2
Crawford	1	1
Dent	1	1
Dunklin	0	1
Franklin	1	1
Gasconade	1	1
Howell	2	2
Jefferson	0	1
Lincoln	1	1
Madison	1	1
Pemiscot	0	1
Perry	0	1
Phelps	1	1
Pike	1	1
Pulaski	1	1
Reynolds	0	1
Ripley	0	1
Saint Charles	5	5
Sainte Genevieve	0	1
Saint Francois	1	4
Saint Louis	12	13
Scott	0	1
Stoddard	0	1
Texas	1	1
Washington	0	1
Saint Louis (City)	0	13
Bollinger	0	0
Carter	0	0
Douglas	0	0
Iron	0	0
Maries	0	0
Miller	0	0
Mississippi	0	0
Montgomery	0	0
New Madrid	0	0
Oregon	0	0
Osage	0	0
Ozark	0	0
Shannon	0	0
Warren	0	0
Wayne	0	0

Legend

Hospital Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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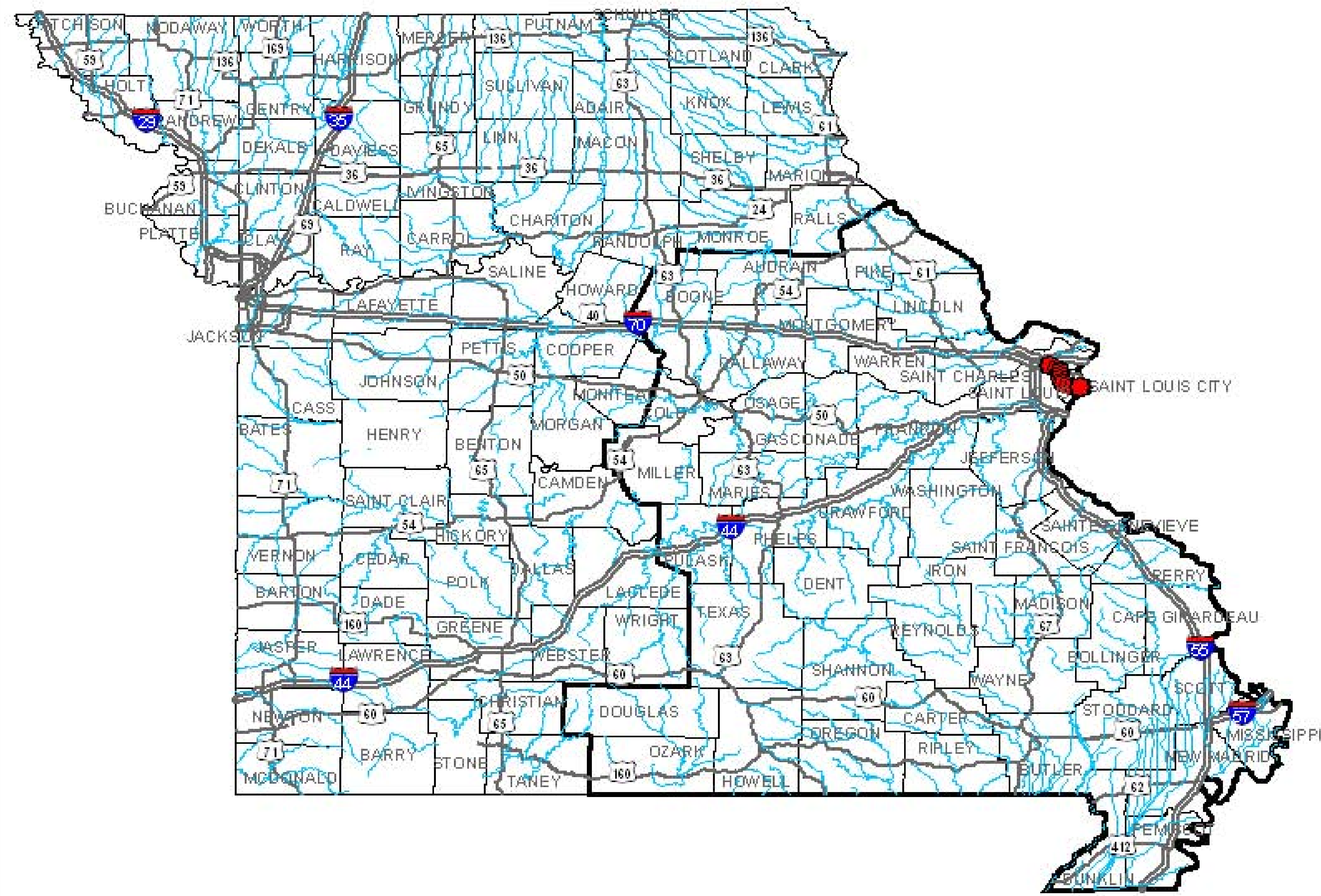
Light Rail Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Saint Louis	7	7	7
Saint Louis (City)	10	10	10
Audrain	0	0	0
Bollinger	0	0	0
Boone	0	0	0
Butler	0	0	0
Callaway	0	0	0
Cape Girardeau	0	0	0
Carter	0	0	0
Cole	0	0	0
Crawford	0	0	0
Dent	0	0	0
Douglas	0	0	0
Dunklin	0	0	0
Franklin	0	0	0
Gasconade	0	0	0
Howell	0	0	0
Iron	0	0	0
Jefferson	0	0	0
Lincoln	0	0	0
Madison	0	0	0
Maries	0	0	0
Miller	0	0	0
Mississippi	0	0	0
Montgomery	0	0	0
New Madrid	0	0	0
Oregon	0	0	0
Osage	0	0	0
Ozark	0	0	0
Pemiscot	0	0	0
Perry	0	0	0
Phelps	0	0	0
Pike	0	0	0
Pulaski	0	0	0
Reynolds	0	0	0
Ripley	0	0	0
Saint Charles	0	0	0
Sainte Genevieve	0	0	0
Saint Francois	0	0	0
Scott	0	0	0
Shannon	0	0	0
Stoddard	0	0	0
Texas	0	0	0
Warren	0	0	0
Washington	0	0	0
Wayne	0	0	0

Legend

Light Rail Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

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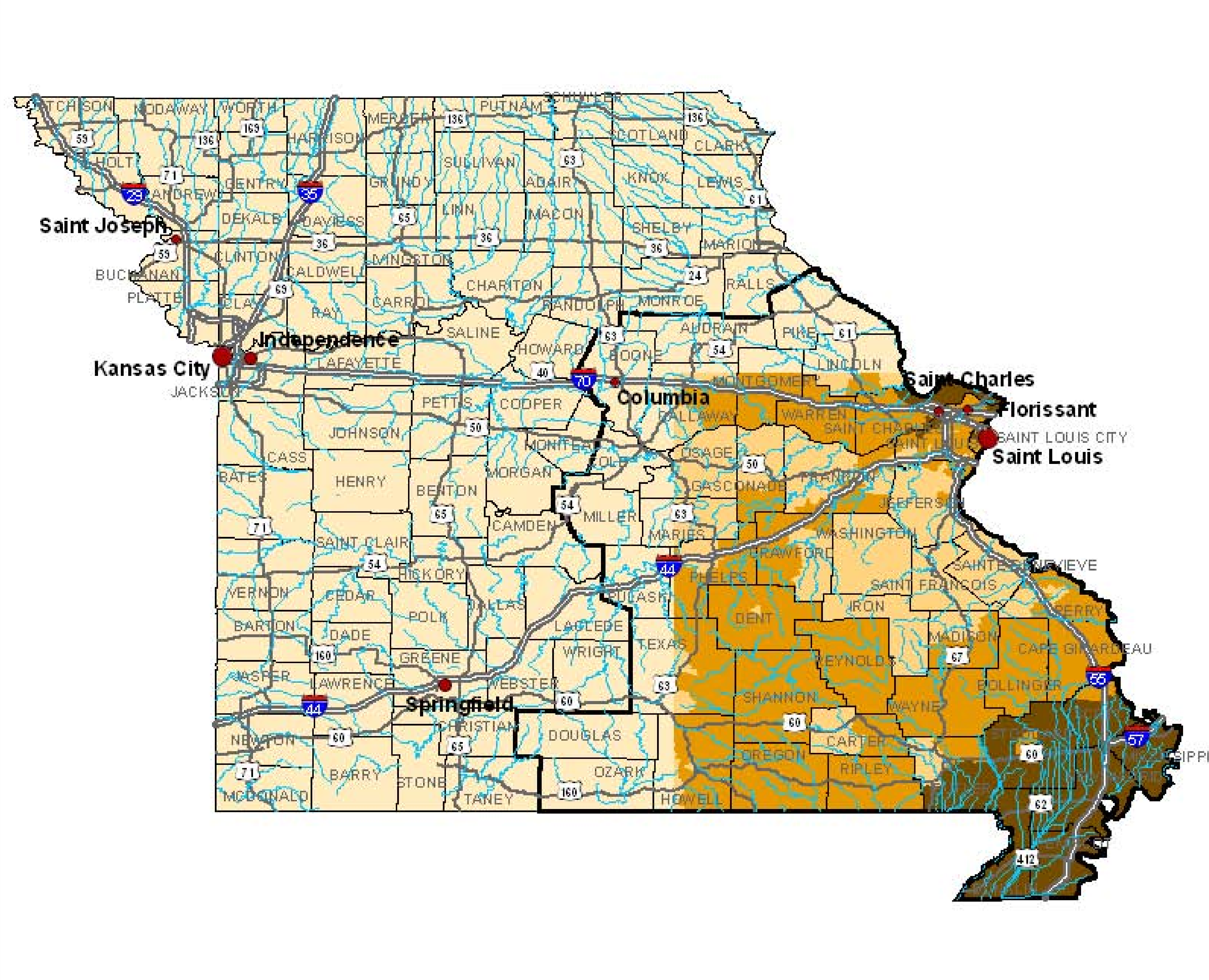
Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Minimum Susceptibility	Maximum Susceptibility
Audrain	Unknown	Unknown
Bollinger	Low	Low
Boone	Unknown	Unknown
Butler	Unknown	Very High
Callaway	Unknown	Low
Cape Girardeau	Unknown	Very High
Carter	None	Low
Cole	Unknown	Unknown
Crawford	None	Low
Dent	None	Low
Douglas	Unknown	Unknown
Dunklin	Unknown	Very High
Franklin	None	Low
Gasconade	None	Low
Howell	Unknown	Low
Iron	None	None
Jefferson	None	Very High
Lincoln	Unknown	Low
Madison	None	Low
Maries	Unknown	None
Miller	Unknown	Unknown
Mississippi	Unknown	Very High
Montgomery	Unknown	Low
New Madrid	Unknown	Very High
Oregon	Unknown	Low
Osage	Unknown	None
Ozark	Unknown	Unknown
Pemiscot	Unknown	Very High
Perry	Unknown	Low
Phelps	Unknown	Low
Pike	Unknown	Unknown
Pulaski	Unknown	Unknown
Reynolds	None	Low
Ripley	Unknown	Low
Saint Charles	Unknown	Very High
Sainte Genevieve	Unknown	None
Saint Francois	None	None
Saint Louis	None	Very High
Scott	Low	Very High
Shannon	Low	Low
Stoddard	Low	Very High
Texas	Unknown	Low
Warren	None	Low
Washington	None	None
Wayne	Low	Low
Saint Louis (City)	None	Very High

Legend

Liquefaction Susceptibility

- Unknown
- None
- Low
- Very High

- Critical Counties
- Interstates
- US Routes
- Rivers

Major Cities

- 50,000 - 75,000
- 75,001 - 150,000
- 150,001 - 444,000

0 15 30 60 90

Miles

Mid-America Earthquake Center

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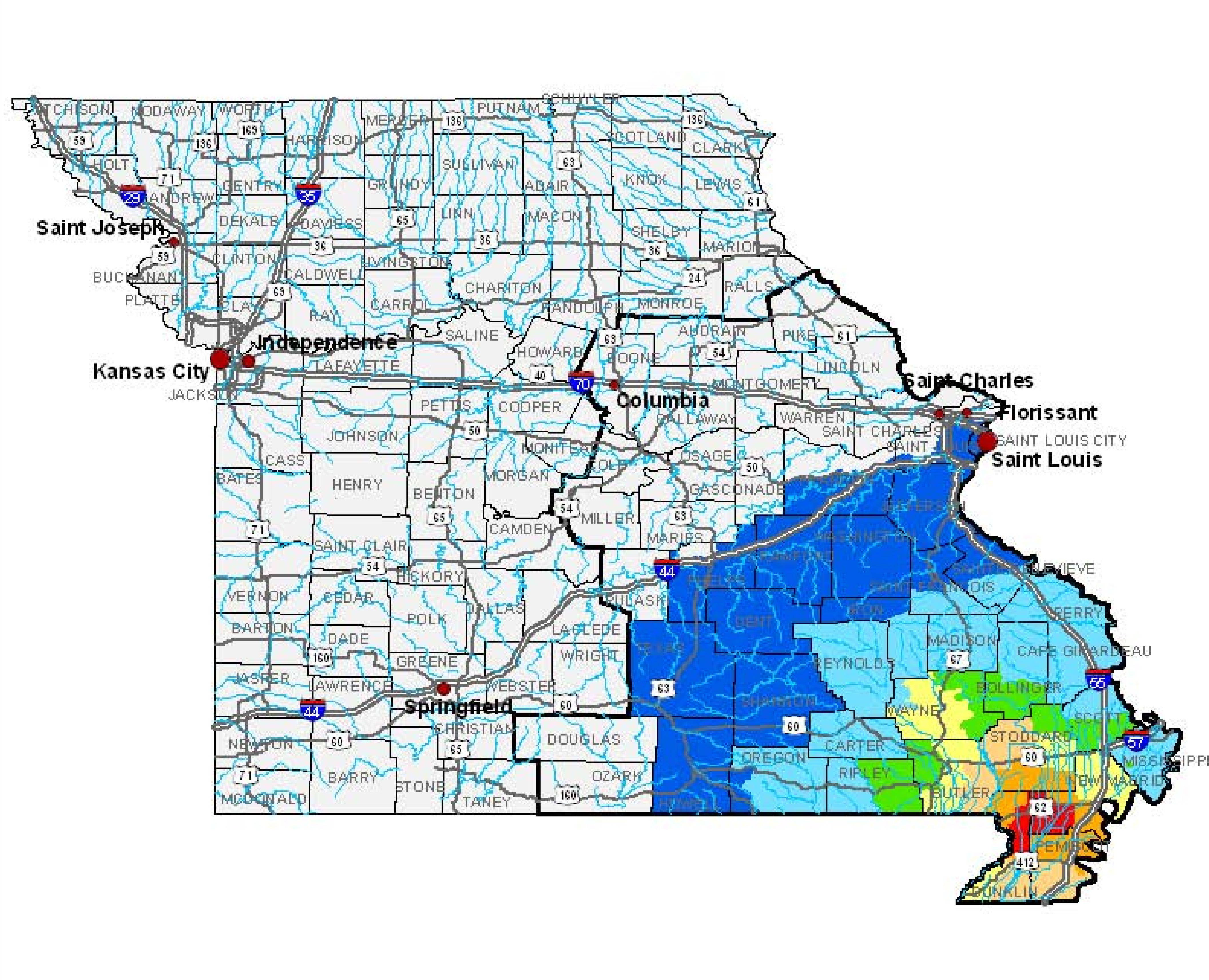
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Max MMI
Audrain	< VI
Bollinger	VIII
Boone	< VI
Butler	XI
Callaway	< VI
Cape Girardeau	VII
Carter	VII
Cole	< VI
Crawford	VI
Dent	VI
Douglas	< VI
Dunklin	XII
Franklin	VI
Gasconade	< VI
Howell	VI
Iron	VII
Jefferson	VI
Lincoln	< VI
Madison	VII
Maries	< VI
Miller	< VI
Mississippi	VIII
Montgomery	< VI
New Madrid	XII
Oregon	VII
Osage	< VI
Ozark	< VI
Pemiscot	XI
Perry	VII
Phelps	VI
Pike	< VI
Pulaski	VI
Reynolds	VII
Ripley	VIII
Saint Charles	< VI
Sainte Genevieve	VII
Saint Francois	VII
Saint Louis	VI
Scott	IX
Shannon	VI
Stoddard	XI
Texas	VI
Warren	< VI
Washington	VI
Wayne	IX
Saint Louis (City)	VI

Legend

Modified Mercalli Intensity (MMI)

- XII
- XI
- X
- IX
- VIII
- VII
- VI
- < VI

Major Cities

- 50,000 - 75,000
- 75,001 - 150,000
- 150,001 - 444,000
- Rivers
- US Routes
- Interstates
- Critical Counties

0 15 30 60 90
Miles

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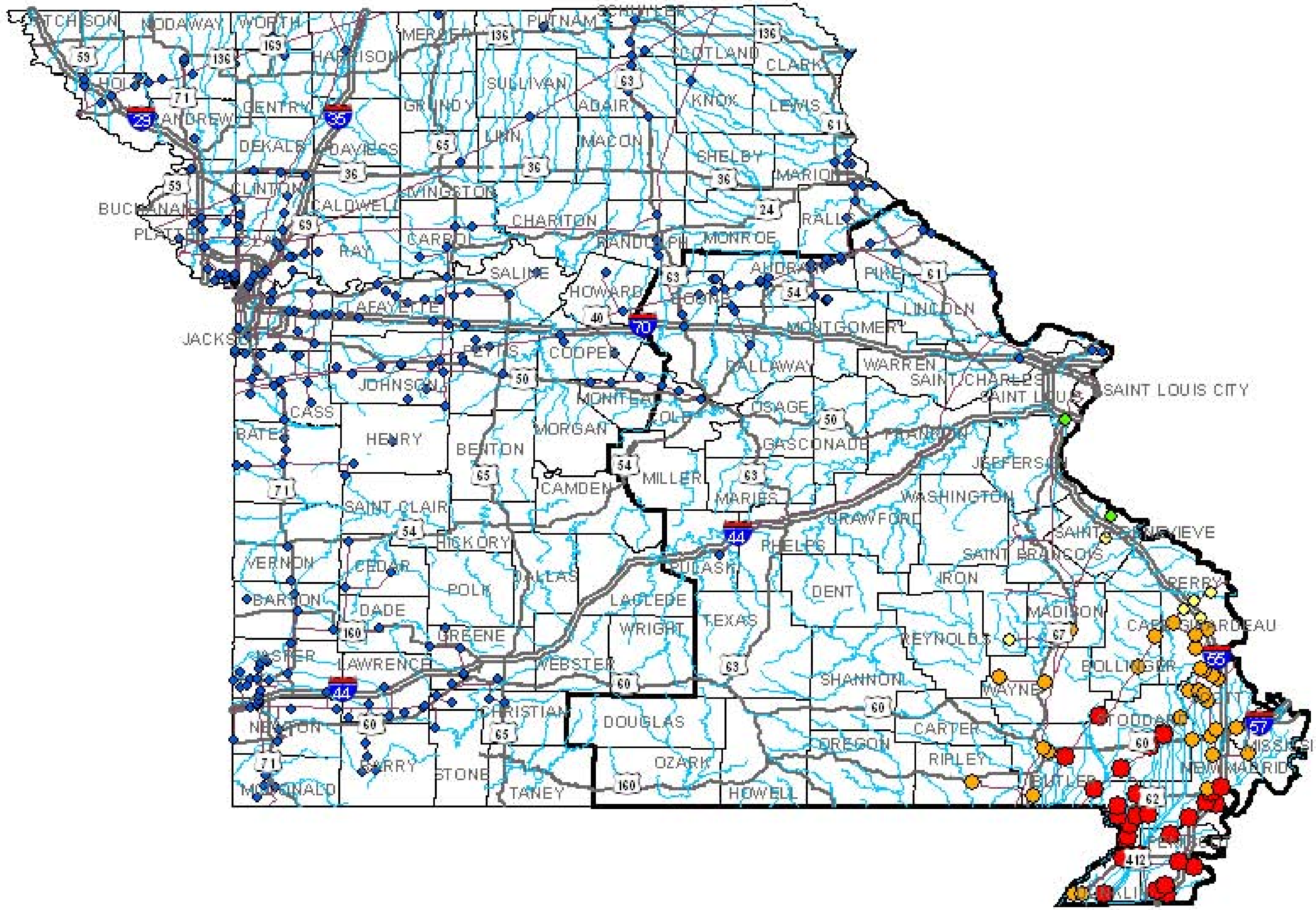
Natural Gas Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	10	0	0
Bollinger	2	2	0
Boone	10	0	0
Butler	5	5	0
Callaway	3	0	0
Cape Girardeau	7	4	0
Cole	3	0	0
Dunklin	12	12	0
Iron	1	0	0
Lincoln	1	0	0
Madison	1	1	0
Mississippi	3	3	0
Montgomery	4	0	0
New Madrid	10	10	1
Pemiscot	6	6	1
Perry	1	0	0
Pike	5	0	0
Pulaski	1	0	0
Ripley	1	1	0
Saint Charles	2	0	0
Sainte Genevieve	2	0	0
Saint Louis	2	0	0
Scott	10	10	0
Stoddard	7	7	1
Wayne	2	2	0
Carter	0	0	0
Crawford	0	0	0
Dent	0	0	0
Douglas	0	0	0
Franklin	0	0	0
Gasconade	0	0	0
Howell	0	0	0
Jefferson	0	0	0
Maries	0	0	0
Miller	0	0	0
Oregon	0	0	0
Osage	0	0	0
Ozark	0	0	0
Phelps	0	0	0
Reynolds	0	0	0
Saint Francois	0	0	0
Shannon	0	0	0
Texas	0	0	0
Warren	0	0	0
Washington	0	0	0
Saint Louis (City)	0	0	0

Legend

Natural Gas Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Major Transmission Lines
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90
Miles

Mid-America Earthquake Center

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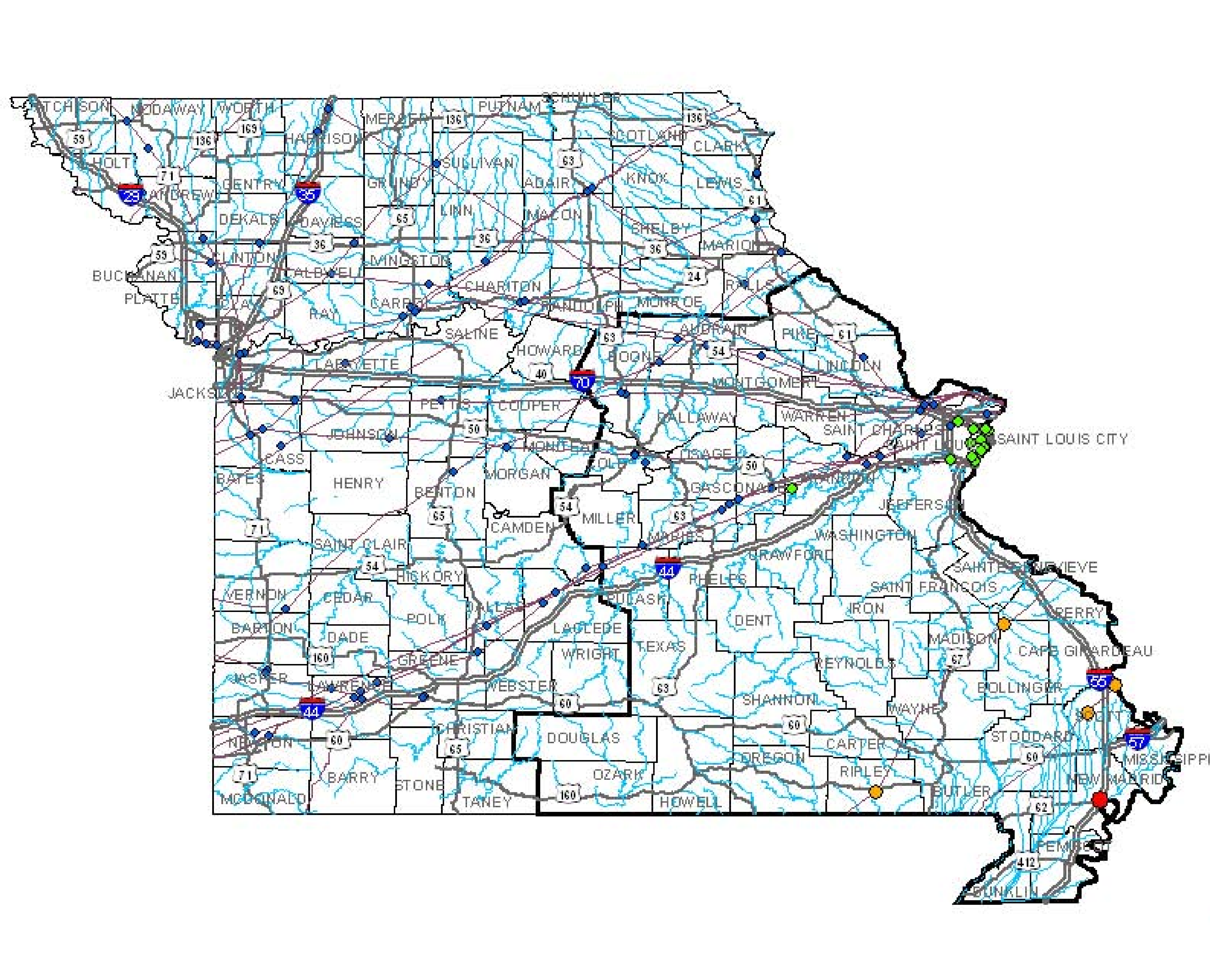
Oil Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	3	0	0
Bollinger	1	1	0
Boone	2	0	0
Cape Girardeau	1	1	0
Cole	3	0	0
Franklin	4	0	0
Gasconade	3	0	0
Lincoln	1	0	0
Maries	3	0	0
Montgomery	1	0	0
New Madrid	1	1	0
Pulaski	1	0	0
Ripley	1	1	0
Saint Charles	3	0	0
Saint Louis	9	0	0
Scott	4	4	0
Saint Louis (City)	11	0	0
Butler	0	0	0
Callaway	0	0	0
Carter	0	0	0
Crawford	0	0	0
Dent	0	0	0
Douglas	0	0	0
Dunklin	0	0	0
Howell	0	0	0
Iron	0	0	0
Jefferson	0	0	0
Madison	0	0	0
Miller	0	0	0
Mississippi	0	0	0
Oregon	0	0	0
Osage	0	0	0
Ozark	0	0	0
Pemiscot	0	0	0
Perry	0	0	0
Phelps	0	0	0
Pike	0	0	0
Reynolds	0	0	0
Sainte Genevieve	0	0	0
Saint Francois	0	0	0
Shannon	0	0	0
Stoddard	0	0	0
Texas	0	0	0
Warren	0	0	0
Washington	0	0	0
Wayne	0	0	0

Legend

Oil Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Major Transmission Lines
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

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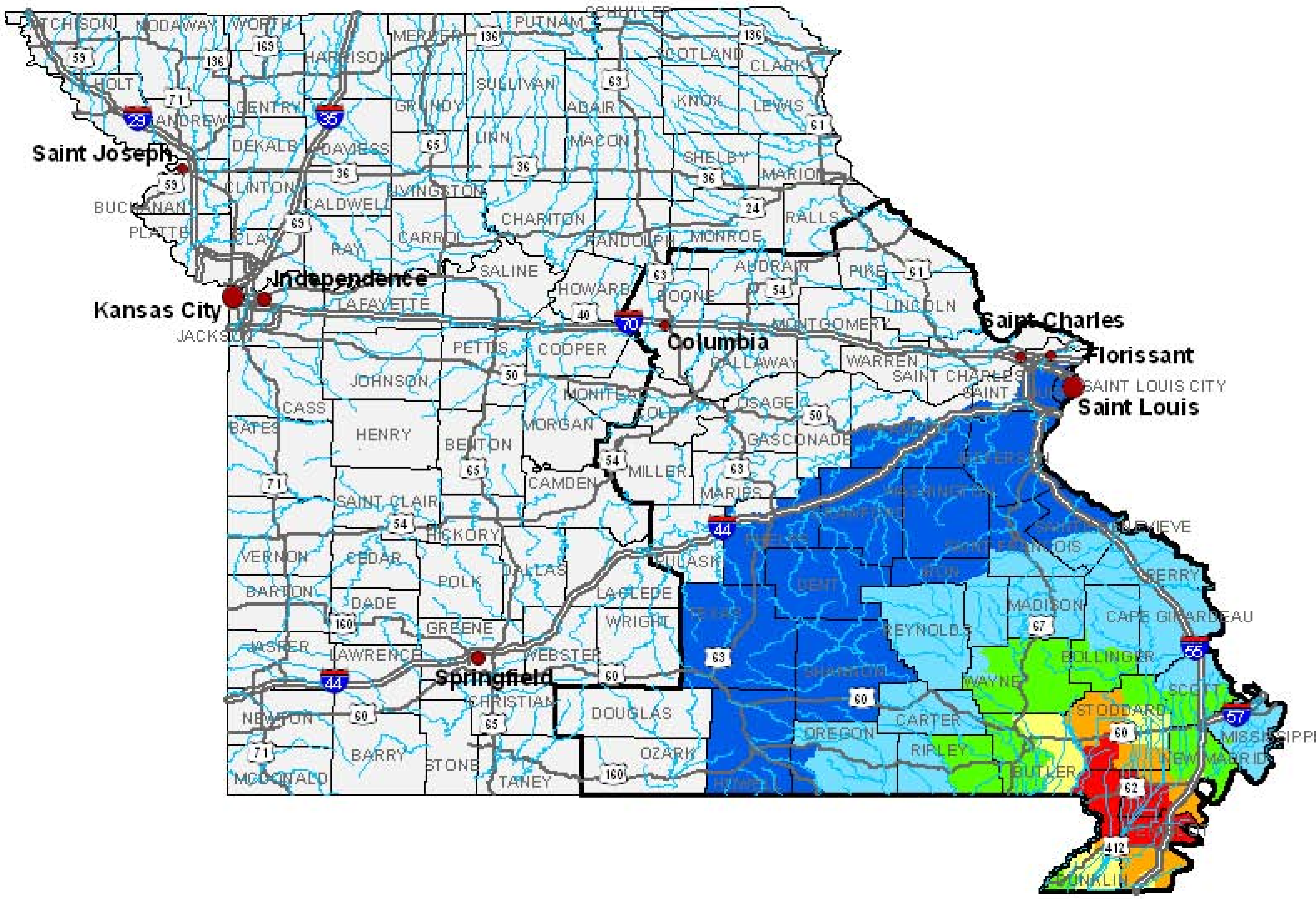
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Min PGA (g)	Max PGA (g)
Audrain	0.05	0.05
Bollinger	0.34	0.44
Boone	0.05	0.05
Butler	0.44	1.34
Callaway	0.05	0.07
Cape Girardeau	0.25	0.34
Carter	0.25	0.34
Cole	0.05	0.07
Crawford	0.15	0.15
Dent	0.15	0.15
Douglas	0.05	0.05
Dunklin	0.55	1.35
Franklin	0.07	0.15
Gasconade	0.07	0.07
Howell	0.15	0.15
Iron	0.15	0.25
Jefferson	0.15	0.15
Lincoln	0.05	0.05
Madison	0.25	0.34
Maries	0.07	0.07
Miller	0.05	0.05
Mississippi	0.34	0.44
Montgomery	0.05	0.05
New Madrid	0.55	1.45
Oregon	0.15	0.25
Osage	0.07	0.07
Ozark	0.05	0.05
Pemiscot	0.75	1.34
Perry	0.25	0.25
Phelps	0.07	0.15
Pike	0.05	0.05
Pulaski	0.05	0.15
Reynolds	0.15	0.25
Ripley	0.25	0.44
Saint Charles	0.05	0.07
Sainte Genevieve	0.15	0.25
Saint Francois	0.15	0.25
Saint Louis	0.05	0.15
Scott	0.34	0.55
Shannon	0.15	0.15
Stoddard	0.44	1.34
Texas	0.05	0.15
Warren	0.05	0.07
Washington	0.15	0.15
Wayne	0.34	0.55
Saint Louis (City)	0.07	0.15

Legend

PGA (g)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.45

- Rivers
- US Routes
- Interstates
- Critical Counties

Major Cities

- 50,000 - 75,000
- 75,001 - 150,000
- 150,001 - 444,000

0 15 30 60 90

Miles

Mid-America Earthquake Center

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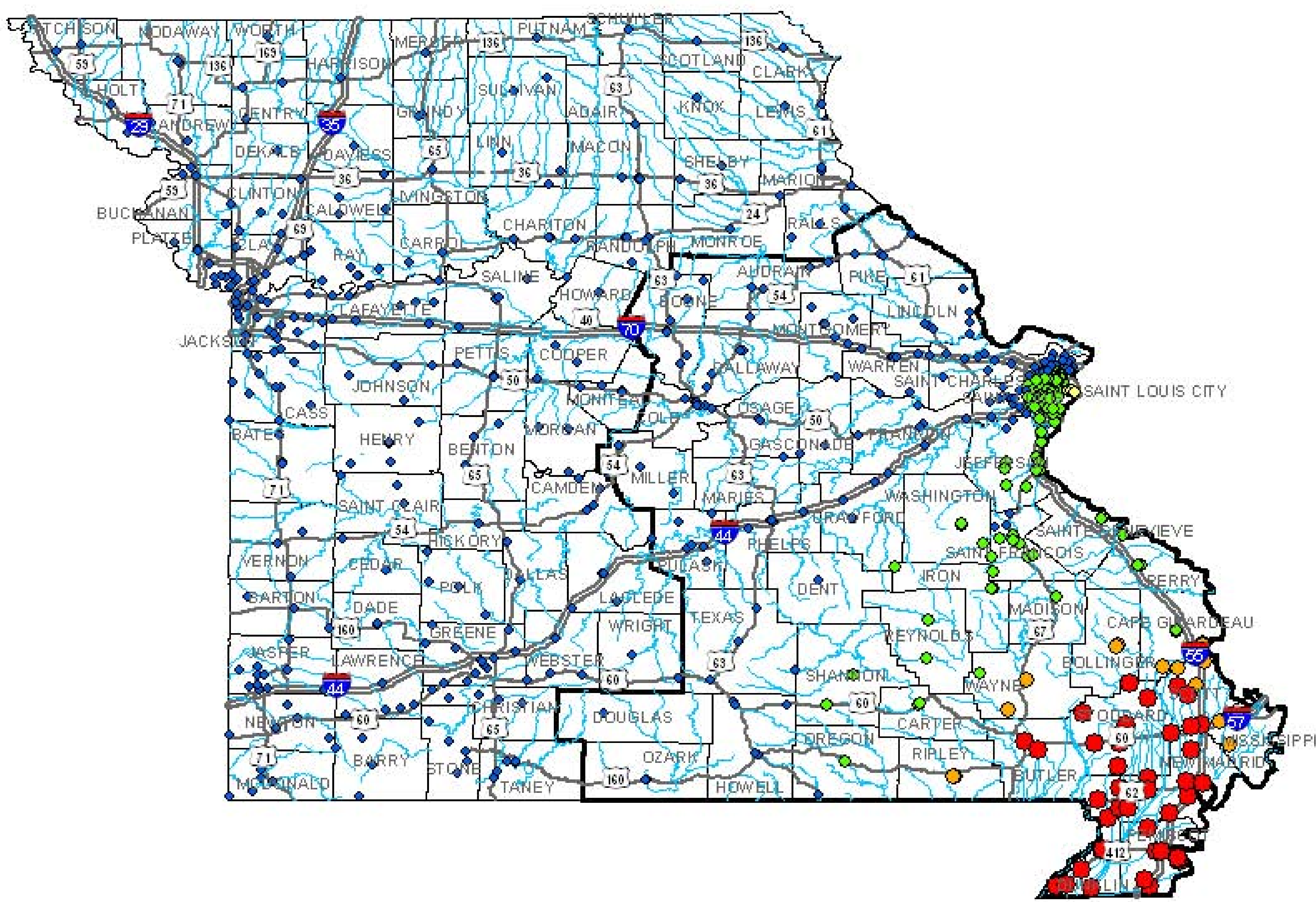
Police Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	4	0	0
Bollinger	2	2	0
Boone	8	0	0
Butler	3	3	3
Callaway	5	0	0
Cape Girardeau	5	3	0
Carter	2	0	0
Cole	8	0	0
Crawford	5	0	0
Dent	2	0	0
Douglas	2	0	0
Dunklin	10	10	10
Franklin	7	0	0
Gasconade	4	0	0
Howell	5	0	0
Iron	3	0	0
Jefferson	14	0	0
Lincoln	7	0	0
Madison	2	0	0
Maries	3	0	0
Miller	4	0	0
Mississippi	4	4	0
Montgomery	7	0	0
New Madrid	11	11	8
Oregon	3	0	0
Osage	2	0	0
Ozark	2	0	0
Pemiscot	8	8	8
Perry	2	0	0
Phelps	6	0	0
Pike	4	0	0
Pulaski	7	0	0
Reynolds	2	0	0
Ripley	2	2	0
Saint Charles	9	0	0
Sainte Genevieve	3	0	0
Saint Francois	11	0	0
Saint Louis	95	0	0
Scott	8	8	0
Shannon	4	0	0
Stoddard	8	8	8
Texas	5	0	0
Warren	5	0	0
Washington	3	0	0
Wayne	3	2	0
Saint Louis (City)	7	0	0

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

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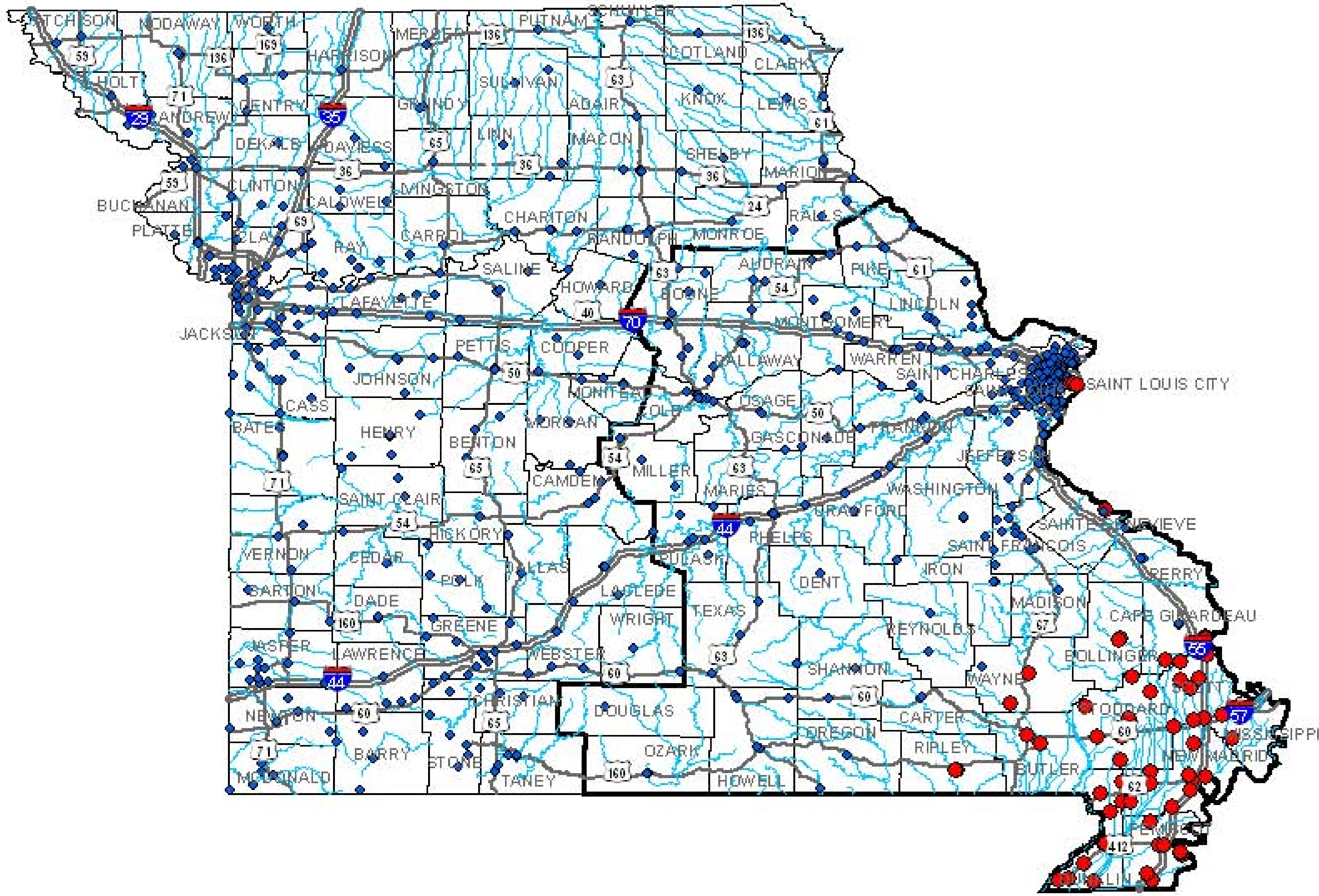
Police Station Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Functional Facilities	Total No. of Facilities
Audrain	4	4
Bollinger	0	2
Boone	8	8
Butler	0	3
Callaway	8	8
Cape Girardeau	2	8
Carter	2	2
Cole	8	8
Crawford	5	5
Dent	2	2
Douglas	2	2
Dunklin	0	10
Franklin	7	7
Gasconade	4	4
Howell	5	5
Iron	3	3
Jefferson	14	14
Lincoln	7	7
Madison	2	2
Maries	3	3
Miller	4	4
Mississippi	0	4
Montgomery	7	7
New Madrid	0	11
Oregon	3	3
Osage	2	2
Ozark	2	2
Pemiscot	0	8
Perry	2	2
Phelps	6	6
Pike	4	4
Pulaski	7	7
Reynolds	2	2
Ripley	0	2
Saint Charles	9	9
Sainte Genevieve	2	3
Saint Francois	11	11
Saint Louis	94	95
Scott	0	8
Shannon	4	4
Stoddard	0	8
Texas	5	5
Warren	5	5
Washington	3	3
Wayne	1	3
Saint Louis (City)	3	7

Legend

Police Station Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

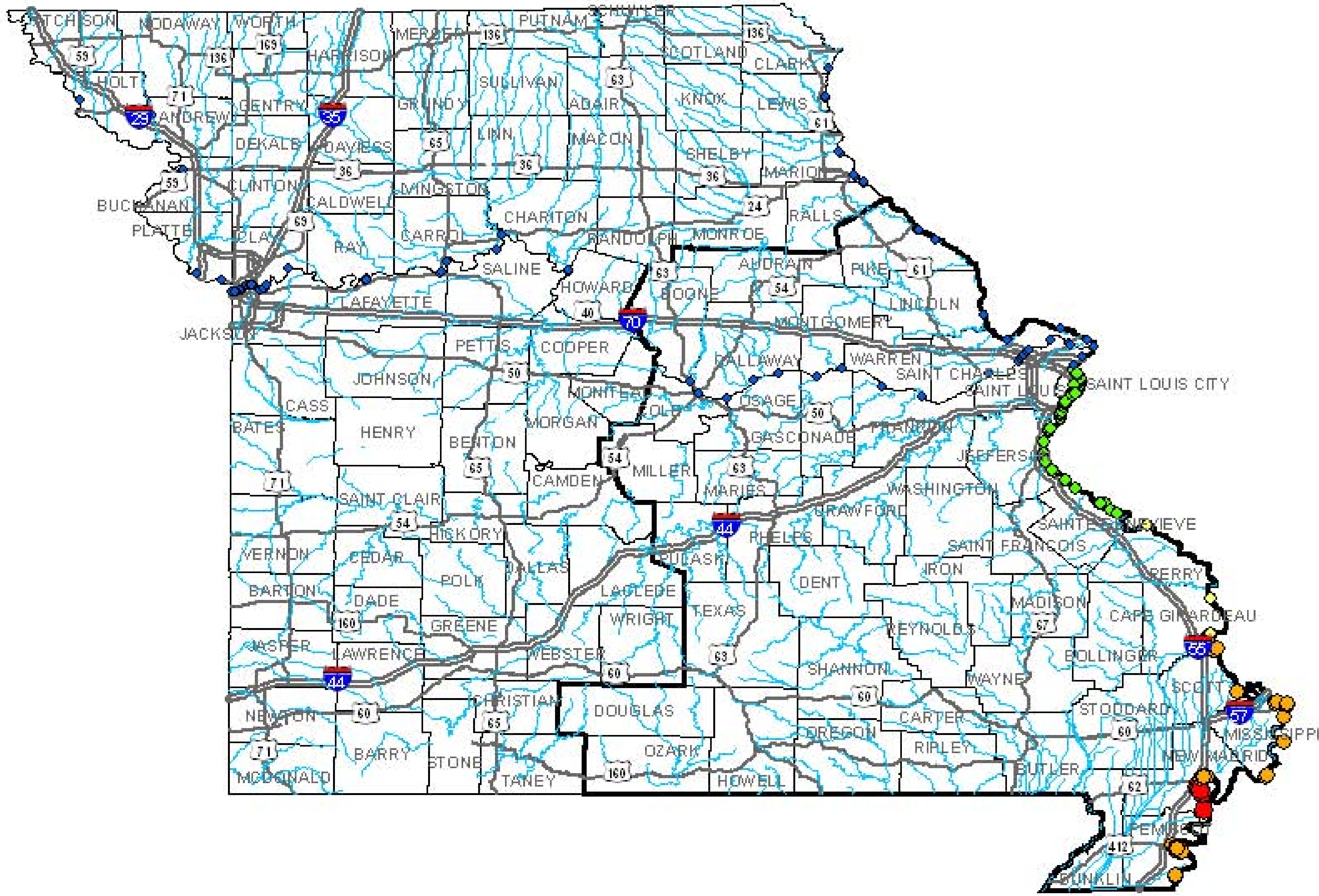
Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Port Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	0	0	0
Bollinger	0	0	0
Boone	0	0	0
Butler	0	0	0
Callaway	5	0	0
Cape Girardeau	13	11	0
Carter	0	0	0
Cole	1	0	0
Crawford	0	0	0
Dent	0	0	0
Douglas	0	0	0
Dunklin	0	0	0
Franklin	1	0	0
Gasconade	1	0	0
Howell	0	0	0
Iron	0	0	0
Jefferson	15	0	0
Lincoln	2	0	0
Madison	0	0	0
Maries	0	0	0
Miller	0	0	0
Mississippi	8	8	0
Montgomery	1	0	0
New Madrid	14	14	0
Oregon	0	0	0
Osage	1	0	0
Ozark	0	0	0
Pemiscot	11	11	0
Perry	2	0	0
Phelps	0	0	0
Pike	4	0	0
Pulaski	0	0	0
Reynolds	0	0	0
Ripley	0	0	0
Saint Charles	6	0	0
Saint Francois	0	0	0
Saint Louis	24	0	0
Saint Louis (City)	52	0	0
Sainte Genevieve	12	0	0
Scott	6	5	0
Shannon	0	0	0
Stoddard	0	0	0
Texas	0	0	0
Warren	2	0	0
Washington	0	0	0
Wayne	0	0	0

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties

Interstates

US Routes

Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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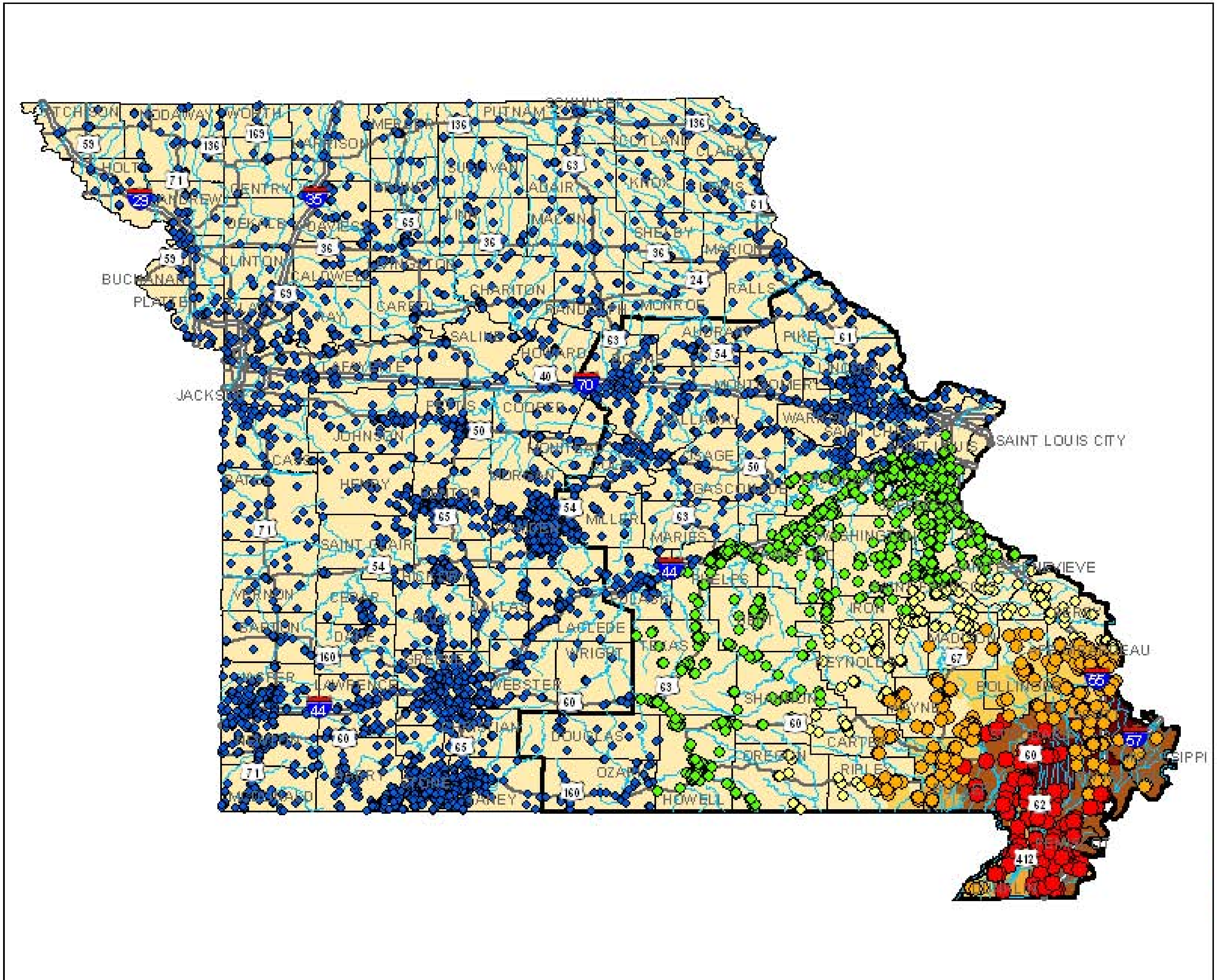
Potable Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	40	0	0
Bollinger	23	23	0
Boone	137	0	0
Butler	86	86	0
Callaway	91	0	0
Cape Girardeau	119	99	0
Carter	28	11	0
Cole	32	0	0
Crawford	87	0	0
Dent	36	0	0
Douglas	33	0	0
Dunklin	63	63	19
Franklin	212	0	0
Gasconade	42	0	0
Howell	81	0	0
Iron	51	0	0
Jefferson	277	0	0
Lincoln	128	0	0
Madison	33	12	0
Maries	27	0	0
Miller	118	0	0
Mississippi	43	43	0
Montgomery	49	0	0
New Madrid	78	78	15
Oregon	28	0	0
Osage	41	0	0
Ozark	86	0	0
Pemiscot	68	68	13
Perry	40	0	0
Phelps	94	0	0
Pike	45	0	0
Pulaski	88	0	0
Reynolds	50	0	0
Ripley	32	24	0
Saint Charles	140	0	0
Sainte Genevieve	54	0	0
Saint Francois	117	0	0
Saint Louis	87	0	0
Scott	84	84	0
Shannon	33	0	0
Stoddard	90	90	7
Texas	62	0	0
Warren	72	0	0
Washington	73	0	0
Wayne	77	77	0
Saint Louis (City)	2	0	0

Legend

Potable Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Rivers
- US Routes
- Interstates
- Critical Counties

Potable Water Distribution Lines

No. Leaks

- 0 - 25
- 25 - 150
- 150 - 300
- 300 - 600
- 600 - 1,125

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

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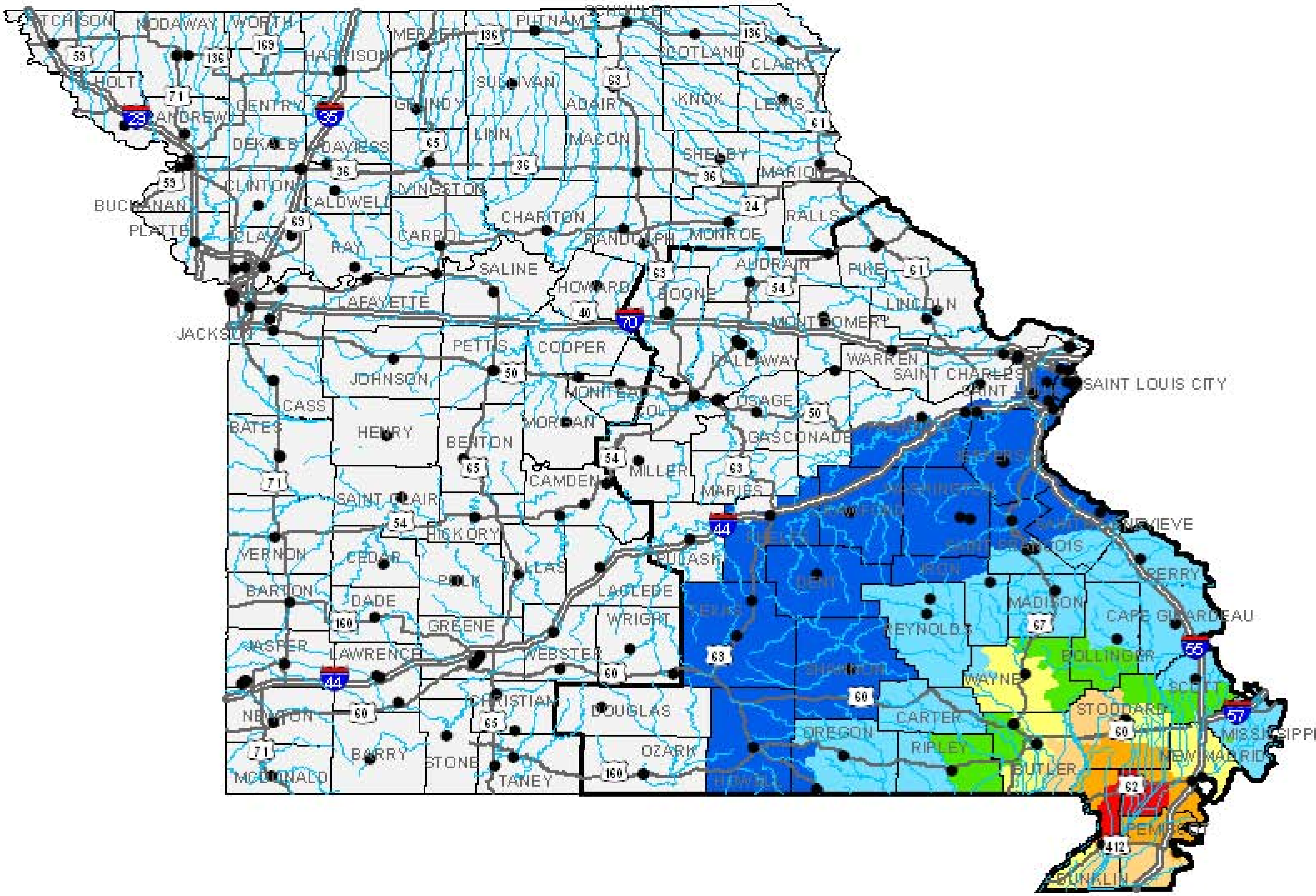
Prisons - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Facilities
Audrain	2
Bollinger	1
Boone	3
Butler	4
Callaway	5
Cape Girardeau	4
Carter	0
Cole	5
Crawford	1
Dent	1
Douglas	1
Dunklin	1
Franklin	2
Gasconade	1
Howell	1
Iron	1
Jefferson	3
Lincoln	2
Madison	1
Maries	1
Miller	1
Mississippi	2
Montgomery	2
New Madrid	2
Oregon	2
Osage	1
Ozark	2
Pemiscot	1
Perry	1
Phelps	1
Pike	2
Pulaski	1
Reynolds	2
Ripley	1
Saint Charles	3
Saint Francois	4
Saint Louis	11
Saint Louis(City)	5
Sainte Genevieve	1
Scott	1
Shannon	1
Stoddard	2
Texas	2
Warren	1
Washington	2
Wayne	1

Legend

- Prisons
- Critical Counties
- Interstates
- US Routes
- Rivers

MMI

- XII
- XI
- X
- IX
- VIII
- VII
- VI
- < VI

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

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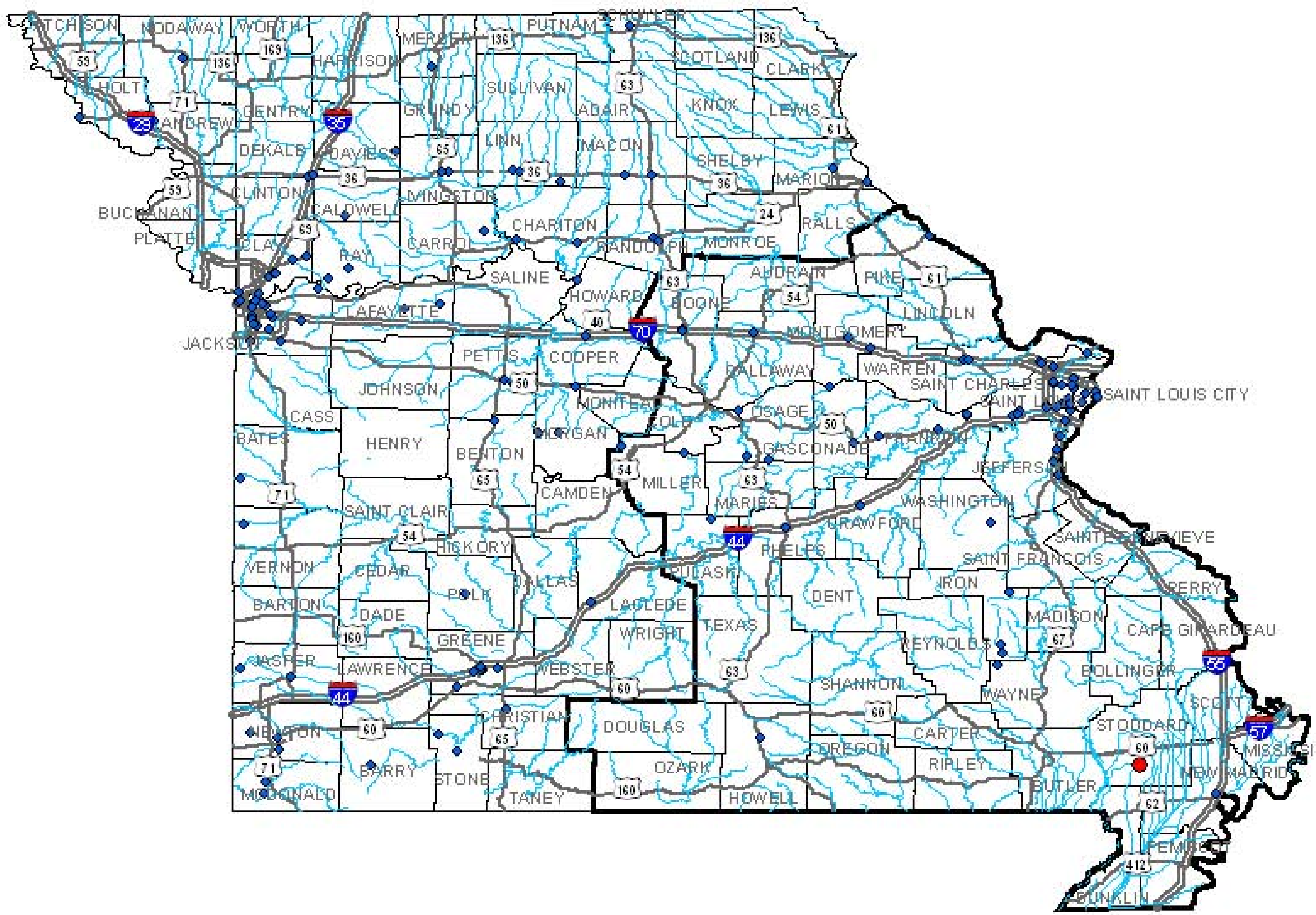
Railway Bridge Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Functional Facilities	Total No. of Facilities
Audrain	0	0
Bollinger	0	0
Boone	3	3
Butler	0	0
Callaway	3	3
Cape Girardeau	0	0
Carter	0	0
Cole	0	0
Crawford	1	1
Dent	0	0
Douglas	0	0
Dunklin	0	0
Franklin	5	5
Gasconade	2	2
Howell	1	1
Iron	3	3
Jefferson	5	5
Lincoln	0	0
Madison	0	0
Maries	0	0
Miller	3	3
Mississippi	0	0
Montgomery	3	3
New Madrid	2	2
Oregon	0	0
Osage	5	5
Ozark	0	0
Pemiscot	0	0
Perry	0	0
Phelps	2	2
Pike	1	1
Pulaski	1	1
Reynolds	0	0
Ripley	0	0
Saint Charles	4	4
Saint Francois	0	0
Saint Louis	33	33
Saint Louis (City)	8	8
Sainte Genevieve	0	0
Scott	0	0
Shannon	0	0
Stoddard	0	2
Texas	0	0
Warren	0	0
Washington	1	1
Wayne	1	1

Legend

Railway Bridge Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

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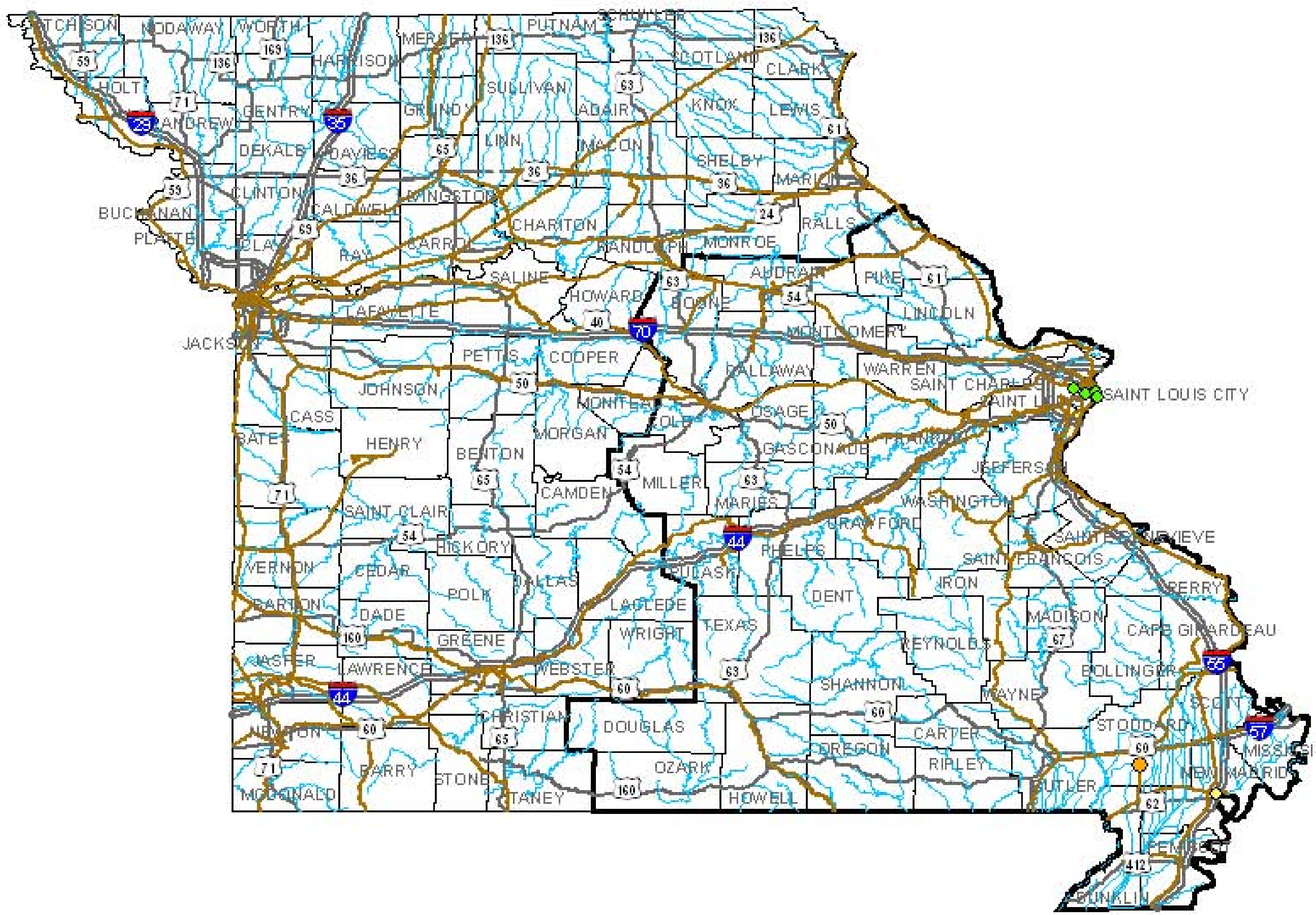
Railway Bridge Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	0	0	0
Bollinger	0	0	0
Boone	3	0	0
Butler	0	0	0
Callaway	3	0	0
Cape Girardeau	0	0	0
Carter	0	0	0
Cole	0	0	0
Crawford	1	0	0
Dent	0	0	0
Douglas	0	0	0
Dunklin	0	0	0
Franklin	5	0	0
Gasconade	2	0	0
Howell	1	0	0
Iron	0	0	0
Jefferson	5	0	0
Lincoln	0	0	0
Madison	0	0	0
Maries	0	0	0
Miller	5	0	0
Mississippi	0	0	0
Montgomery	3	0	0
New Madrid	2	0	0
Oregon	0	0	0
Osage	0	0	0
Ozark	0	0	0
Pemiscot	0	0	0
Perry	0	0	0
Phelps	2	0	0
Pike	1	0	0
Pulaski	1	0	0
Reynolds	0	0	0
Ripley	0	0	0
Saint Charles	4	0	0
Saint Francois	0	0	0
Saint Louis	[illegible]	0	0
Saint Louis (City)	8	0	0
Sainte Genevieve	0	0	0
Scott	0	0	0
Shannon	0	0	0
Stoddard	2	2	0
Texas	0	0	0
Warren	0	0	0
Washington	1	0	0
Wayne	1	0	0

Legend

Railway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Railway Segments
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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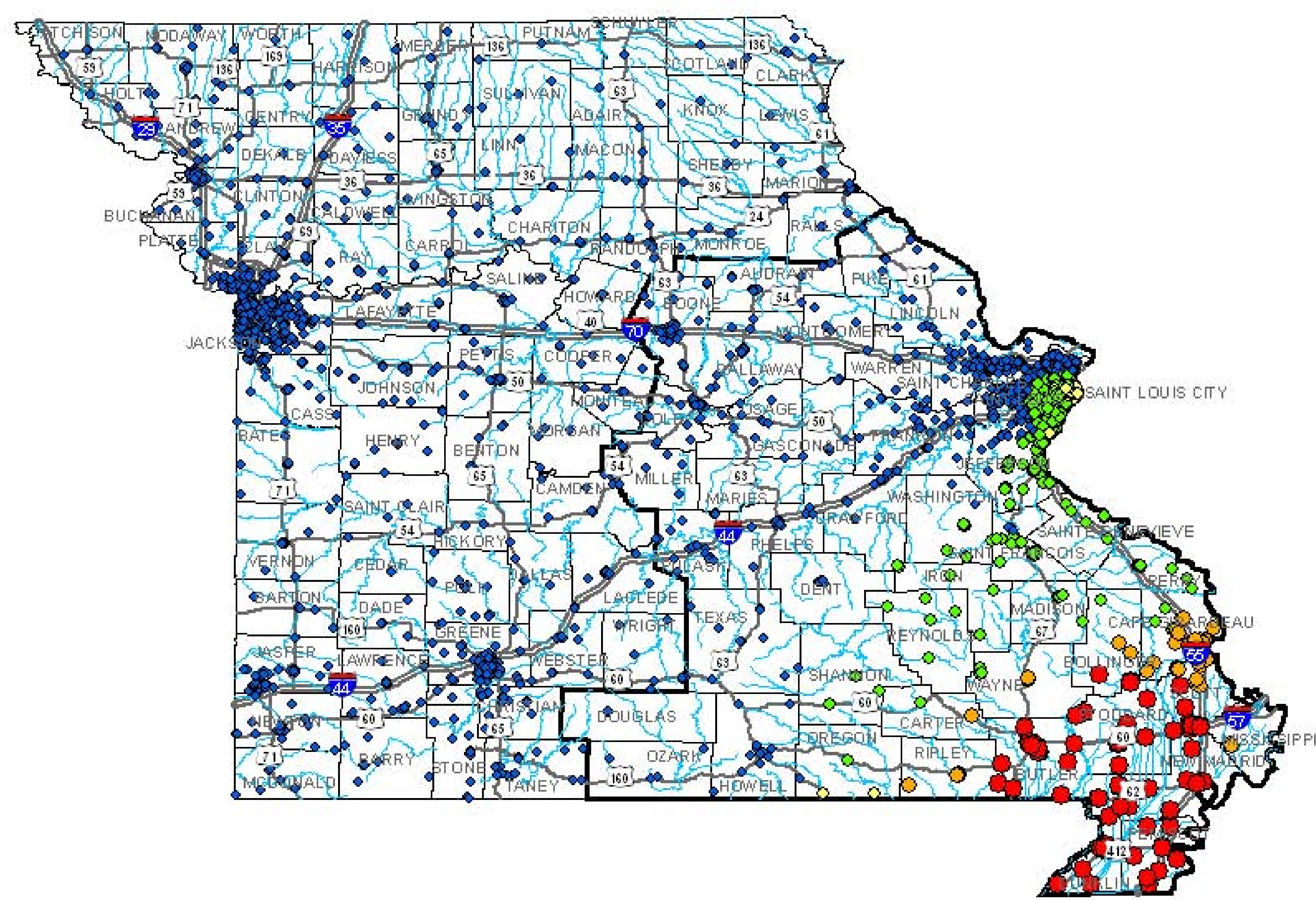
School Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	15	0	0
Bollinger	8	8	0
Boone	57	0	0
Butler	21	21	21
Callaway	23	0	0
Cape Girardeau	37	28	0
Carter	6	3	0
Cole	34	0	0
Crawford	13	0	0
Dent	9	0	0
Douglas	3	0	0
Dunklin	21	21	21
Franklin	68	0	0
Gasconade	11	0	0
Howell	19	0	0
Iron	9	0	0
Jefferson	71	0	0
Lincoln	20	0	0
Madison	5	0	0
Maries	5	0	0
Miller	14	0	0
Mississippi	10	10	0
Montgomery	8	0	0
New Madrid	15	15	7
Oregon	6	0	0
Osage	12	0	0
Ozark	4	0	0
Pemiscot	19	19	19
Perry	10	0	0
Phelps	21	0	0
Pike	13	0	0
Pulaski	23	0	0
Reynolds	8	0	0
Ripley	11	11	1
Saint Charles	88	0	0
Sainte Genevieve	9	0	0
Saint Francois	27	0	0
Saint Louis	421	0	0
Scott	31	31	0
Shannon	4	0	0
Stoddard	20	20	17
Texas	14	0	0
Warren	11	0	0
Washington	14	0	0
Wayne	7	3	0
Saint Louis (City)	159	0	0

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Interstates
US Routes
Rivers

0 15 30 60 90
Miles

Mid-America Earthquake Center

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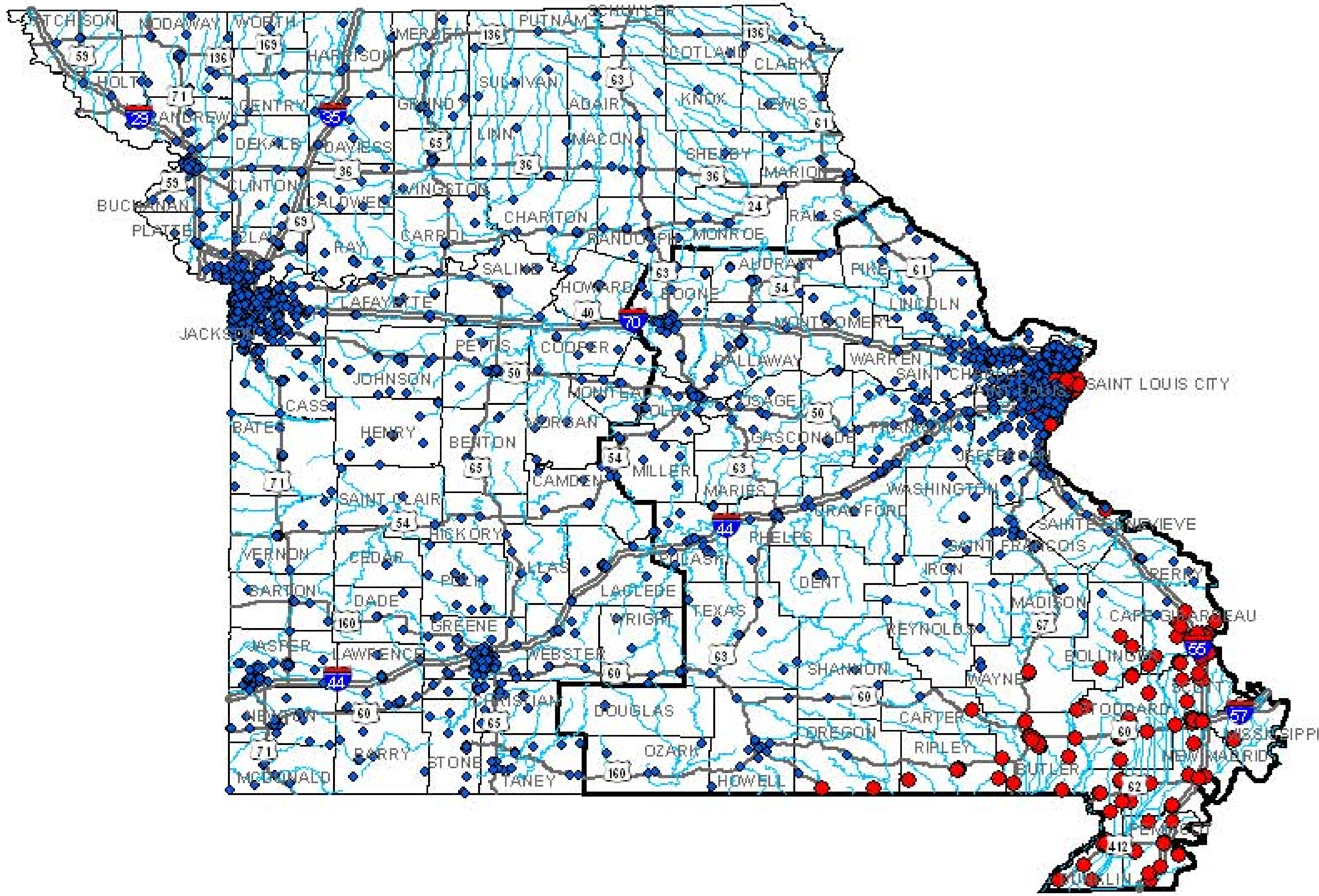
School Functionality at Day 1 - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	No. of Functional Facilities	Total No. of Facilities
Audrain	15	15
Bollinger	2	8
Boone	57	57
Butler	0	21
Callaway	23	23
Cape Girardeau	11	37
Carter	3	6
Cole	34	34
Crawford	13	13
Dent	9	9
Douglas	3	3
Dunklin	0	21
Franklin	58	58
Gasconade	11	11
Howell	19	19
Iron	9	9
Jefferson	71	71
Lincoln	20	20
Madison	5	5
Maries	6	6
Miller	14	14
Mississippi	0	10
Montgomery	8	8
New Madrid	0	15
Oregon	5	8
Osage	12	12
Ozark	4	4
Pemiscot	0	19
Perry	10	10
Phelps	21	21
Pike	13	13
Pulaski	23	23
Reynolds	8	8
Ripley	0	11
Saint Charles	88	88
Sainte Genevieve	8	9
Saint Francois	27	27
Saint Louis	415	421
Scott	0	31
Shannon	4	4
Stoddard	0	20
Texas	14	14
Warren	11	11
Washington	14	14
Wayne	4	7
Saint Louis (City)	87	159

Legend

School Functionality

Day 1

- Not Functional
- Functional
- Critical Counties
- Interstates
- US Routes
- Rivers

0 15 30 60 90

Miles

Mid-America Earthquake Center

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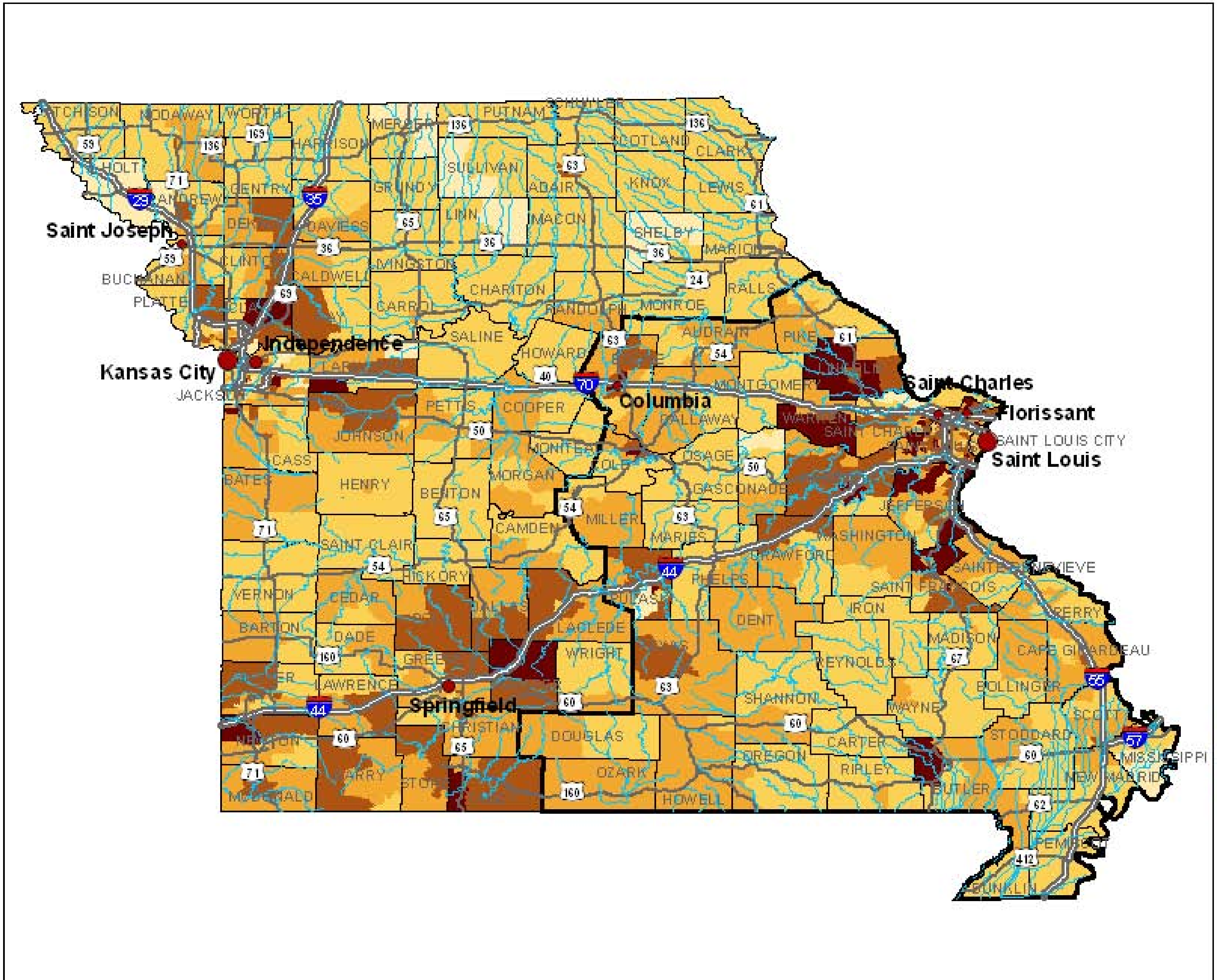
Total Population (2000) - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Population
Audrain	25853
Bollinger	12029
Boone	135454
Butler	40748
Callaway	40766
Cape Girardeau	68693
Carter	5941
Cole	74629
Crawford	22804
Dent	14927
Douglas	13084
Dunklin	37578
Franklin	93807
Gasconade	15342
Howell	37238
Iron	10697
Jefferson	198099
Lincoln	38944
Madison	11800
Maries	8903
Miller	23564
Mississippi	13427
Montgomery	12136
New Madrid	19760
Oregon	10344
Osage	13062
Ozark	9542
Pemiscot	22312
Perry	23048
Phelps	39825
Pike	18351
Pulaski	40882
Reynolds	12888
Ripley	13509
Saint Charles	291883
Sainte Genevieve	17842
Saint Francois	55641
Saint Louis	1016315
Scott	40892
Shannon	8324
Stoddard	29891
Texas	28892
Warren	35344
Washington	23344
Wayne	13259
Saint Louis (City)	348189

Legend

Total Population (2000) (HAZUS)

- 0 - 2,000
- 2,001 - 4,000
- 4,001 - 6,000
- 6,001 - 8,000
- 8,001 - 13,750

Rivers
US Routes
Interstates
Critical Counties

Major Cities

- 50,000 - 75,000
- 75,001 - 150,000
- 150,001 - 444,000

0 15 30 60 90
Miles

Mid-America Earthquake Center

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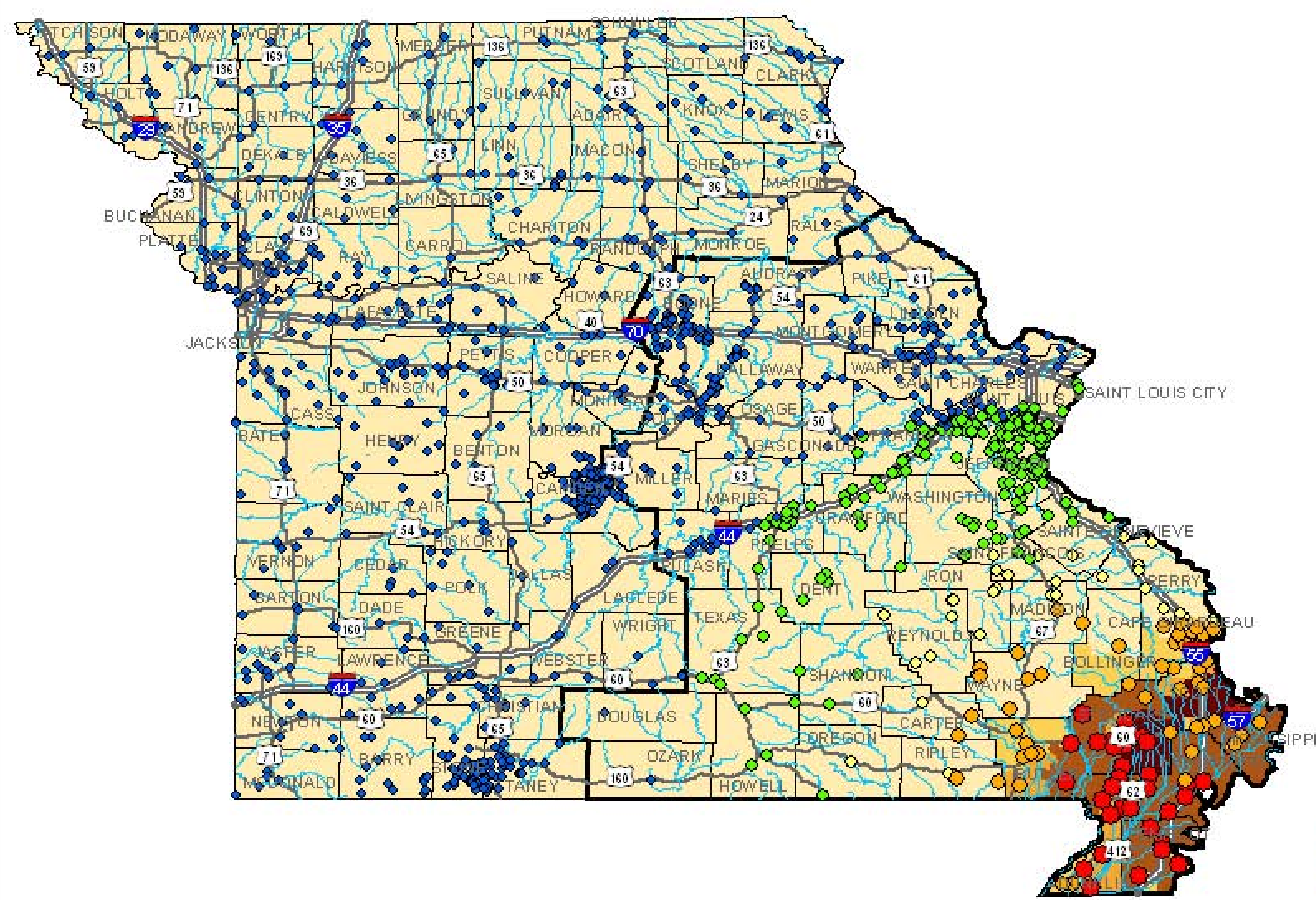
Waste Water Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Missouri Critical Counties (46)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Audrain	12	0	0
Bollinger	1	1	0
Boone	31	0	0
Butler	9	9	0
Callaway	27	0	0
Cape Girardeau	19	14	0
Carter	3	2	0
Cole	25	0	0
Crawford	8	0	0
Dent	5	0	0
Douglas	1	0	0
Dunklin	9	9	3
Franklin	25	0	0
Gasconade	9	0	0
Howell	4	0	0
Iron	6	0	0
Jefferson	81	0	0
Lincoln	18	0	0
Madison	5	2	0
Maries	2	0	0
Miller	16	0	0
Mississippi	6	6	0
Montgomery	10	0	0
New Madrid	11	11	3
Oregon	2	0	0
Osage	4	0	0
Ozark	1	0	0
Pemiscot	5	5	2
Perry	5	0	0
Phelps	19	0	0
Pike	7	0	0
Pulaski	12	0	0
Reynolds	6	0	0
Ripley	4	3	0
Saint Charles	16	0	0
Sainte Genevieve	6	0	0
Saint Francois	12	0	0
Saint Louis	27	0	0
Scott	9	9	0
Shannon	4	0	0
Stoddard	11	11	0
Texas	6	0	0
Warren	18	0	0
Washington	7	0	0
Wayne	6	6	0
Saint Louis (City)	2	0	0

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Rivers
- US Routes
- Interstates
- Critical Counties

Waste Water Distribution Lines

No. Leaks

- 0 - 25
- 25 - 100
- 100 - 250
- 250 - 500
- 500 - 900

0 15 30 60 90

Miles

Mid-America Earthquake Center

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Theresa Jefferson, Principal Investigator

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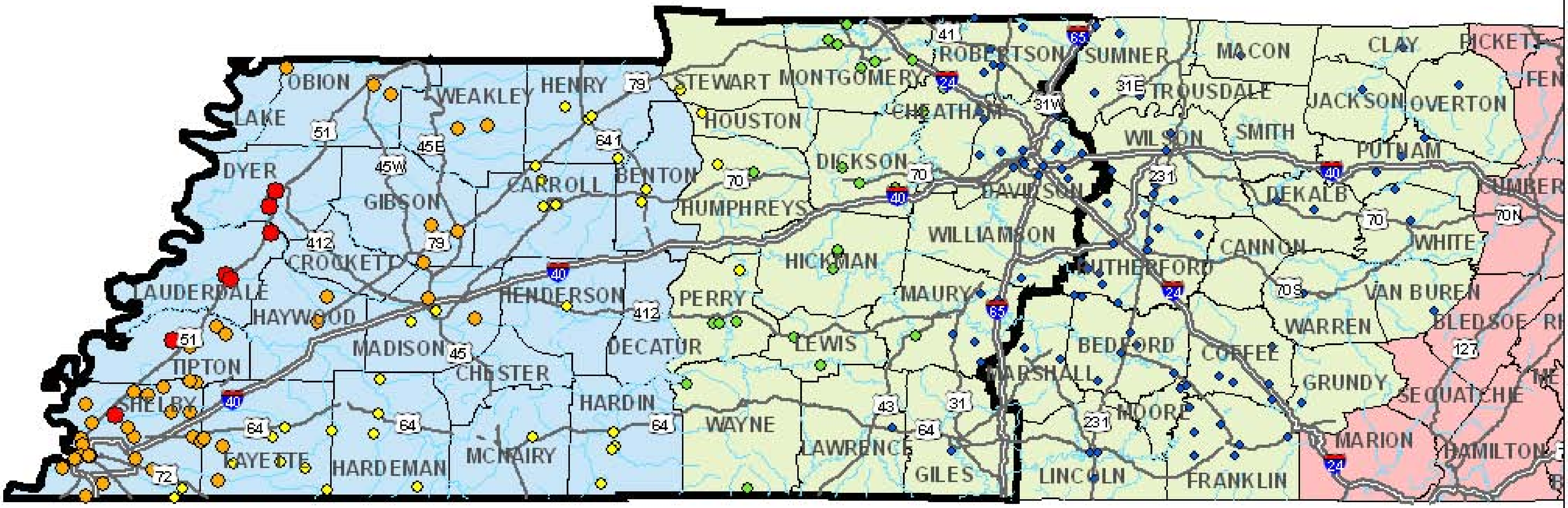
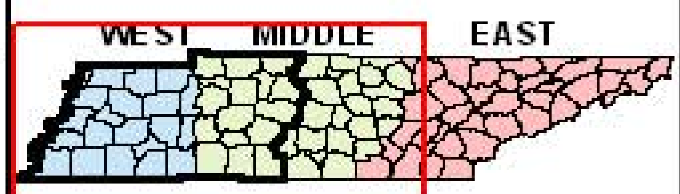
Airport Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	2	0	0
Carroll	4	0	0
Cheatham	5	0	0
Chester	0	0	0
Crockett	0	0	0
Davidson	14	0	0
Decatur	2	0	0
Dickson	3	0	0
Dyer	2	2	1
Fayette	9	3	0
Gibson	3	3	0
Giles	1	0	0
Hardeman	5	0	0
Hardin	4	0	0
Haywood	2	2	0
Henderson	1	0	0
Henry	4	0	0
Hickman	3	0	0
Houston	1	0	0
Humphreys	2	0	0
Lake	1	1	0
Lauderdale	3	3	1
Lawrence	1	0	0
Lewis	2	0	0
Madison	4	2	0
Maury	6	0	0
McNairy	1	0	0
Montgomery	6	0	0
Obion	2	2	0
Perry	4	0	0
Robertcon	6	0	0
Shelby	26	24	0
Stewart	1	0	0
Tipton	6	6	0
Wayne	2	0	0
Weakley	2	2	0
Williamcon	1	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Airport Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

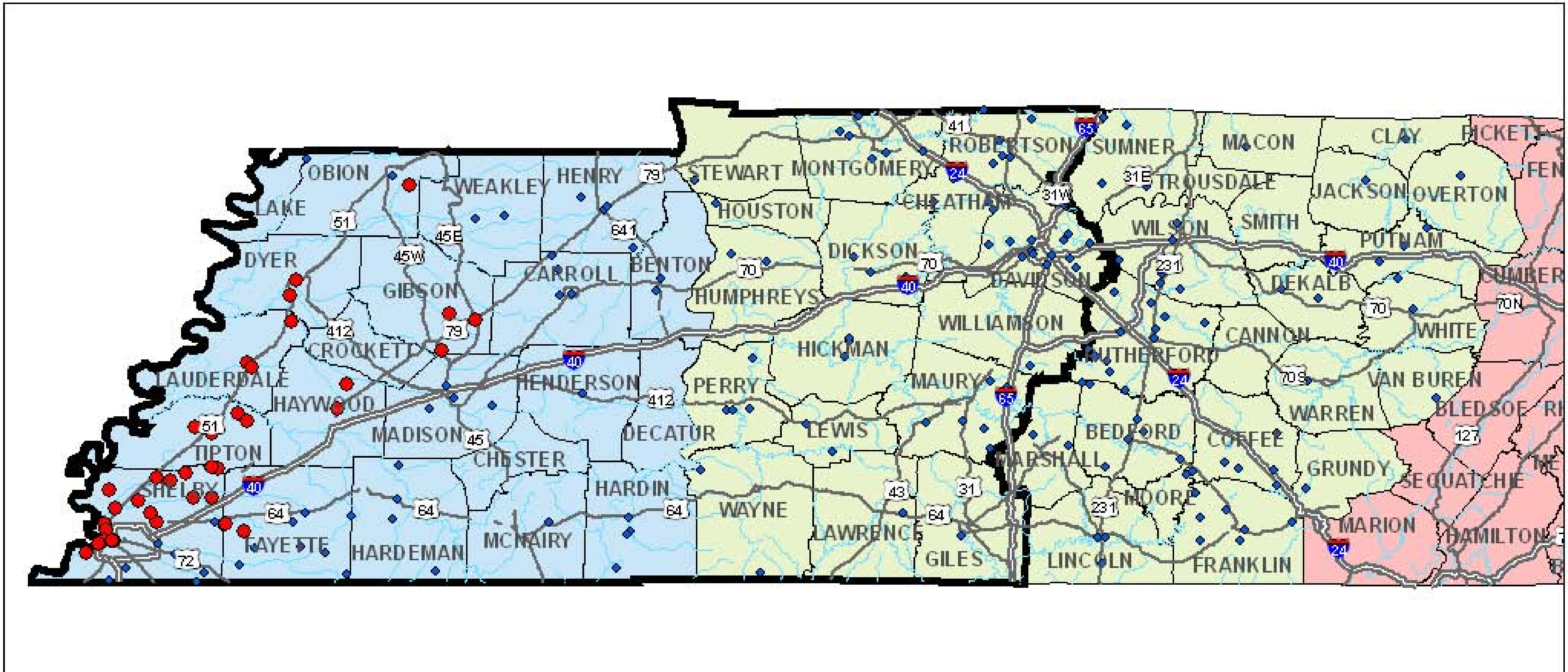
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

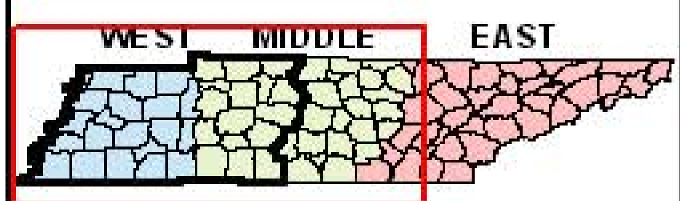
Airport Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Functional Facilities	Total No. of Facilities	County	No. of Functional Facilities	Total No. of Facilities
Benton	2	2	Humphreys	2	2
Carroll	4	4	Lake	1	1
Cheatham	5	5	Lauderdale	0	3
Chester	0	0	Lawrence	1	1
Crockett	0	0	Lewis	2	2
Davidson	14	14	Madison	4	4
Decatur	2	2	Maury	6	6
Dickson	3	3	McNairy	1	1
Dyer	0	2	Montgomery	6	6
Fayette	7	9	Obion	1	2
Gibson	0	3	Perry	4	4
Giles	1	1	Robertson	6	6
Hardeman	5	5	Shelby	8	26
Hardin	4	4	Stewart	1	1
Haywood	0	2	Tipton	0	6
Henderson	1	1	Wayne	2	2
Henry	4	4	Weakley	2	2
Hickman	3	3	Williamson	1	1
Houston	1	1			



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Airport Functionality

Day 1

- Non-Functional
- Functional
- Rivers
- Interstates
- Critical Counties
- US Routes

- West Region
- Middle Region
- East Region

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

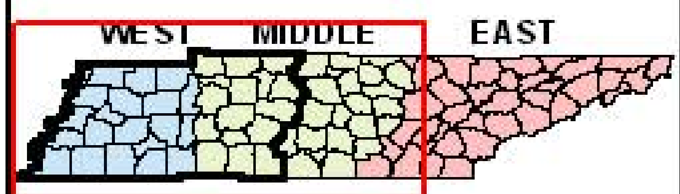
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Worst Case Casualties (2PM) - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Tennessee - Critical Counties (37)

County	No. of Injuries (Minor & Severe)	No. of Fatalities	Total No. of Casualties
Benton	5	0	5
Carroll	184	8	192
Cheatham	0	0	0
Chester	62	3	65
Crockett	436	30	467
Davidson	9	0	9
Decatur	22	1	23
Dickson	0	0	0
Dyer	2,032	142	2,174
Fayette	353	21	374
Gibson	1,321	86	1,407
Giles	0	0	0
Hardeman	213	10	222
Hardin	99	6	105
Haywood	509	33	542
Henderson	171	7	178
Henry	193	9	202
Hickman	0	0	0
Houston	0	0	0
Humphreys	3	0	3
Lake	128	7	135
Lauderdale	972	66	1,038
Lawrence	0	0	0
Lewis	0	0	0
McNairy	89	4	93
Madison	1,194	62	1,255
Maury	1	0	1
Montgomery	1	0	1
Obion	569	35	604
Perry	2	0	2
Robertson	0	0	0
Shelby	32,381	2,225	34,606
Stewart	8	0	8
Tipton	1,524	104	1,627
Wayne	1	0	1
Weakley	687	45	732
Williamson	2	0	2



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Worst Case Casualties (2 PM)

- 0 - 50
- 51 - 250
- 251 - 1,000
- 1,001 - 2,000
- 2,000 - 3,760
- Rivers
- Interstates
- Critical Counties
- US Routes

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

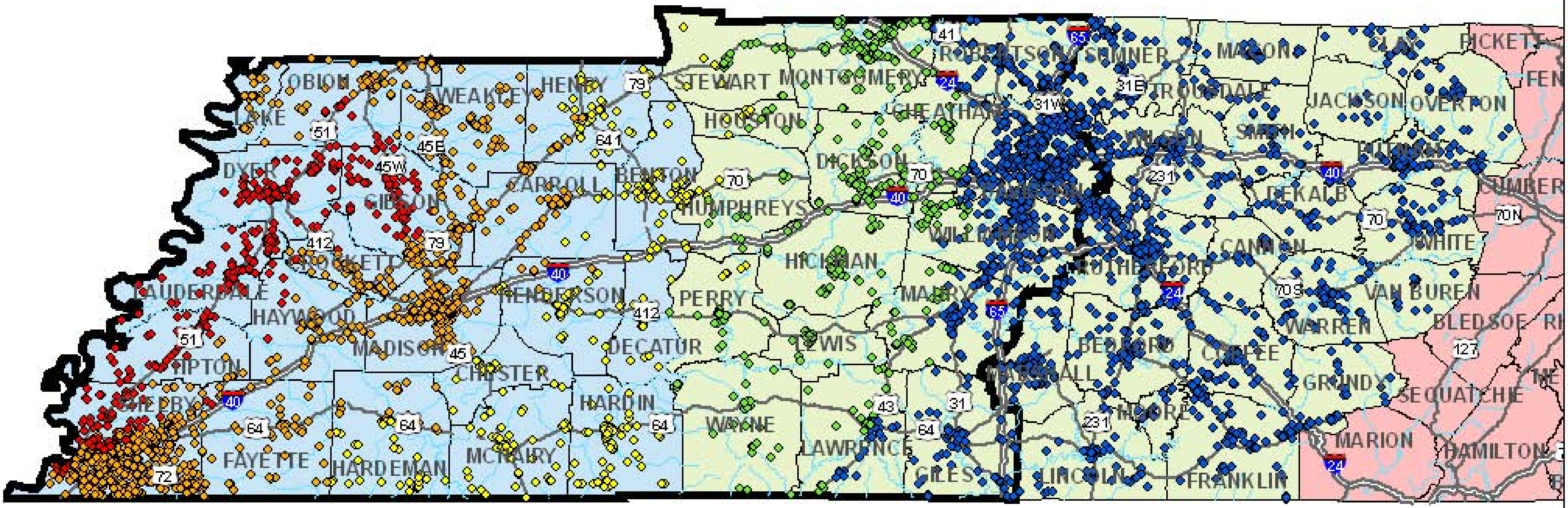
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigation

Communication Facility Damage - New Madrid Seismic Zone: M7.7 Event

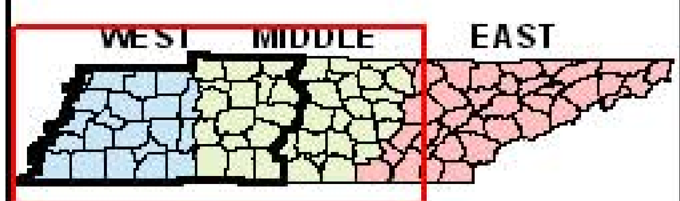
March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	64	0	0
Carroll	96	80	0
Cheatham	71	0	0
Chester	35	0	0
Crockett	75	75	0
Davidson	1205	0	0
Decatur	35	0	0
Dickson	138	0	0
Dyer	159	159	26
Fayette	129	129	0
Gibson	245	245	0
Giles	104	0	0
Hardeman	94	42	0
Hardin	107	0	0
Haywood	99	99	0
Henderson	101	29	0
Henry	120	23	0
Hickman	76	0	0
Houston	24	0	0

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Humphreys	83	0	0
Lake	35	35	0
Lauderdale	110	110	11
Lawrence	143	0	0
Lewis	38	0	0
McNairy	95	0	0
Madison	394	394	0
Maury	163	0	0
Montgomery	252	0	0
Obion	192	192	0
Perry	56	0	0
Robertson	151	0	0
Shelby	1596	1596	0
Stewart	51	0	0
Tipton	121	121	11
Wayne	63	0	0
Weakley	139	139	0
Williamson	310	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Communication Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Rivers
Interstates
Critical Counties
US Routes

West Region
Middle Region
East Region

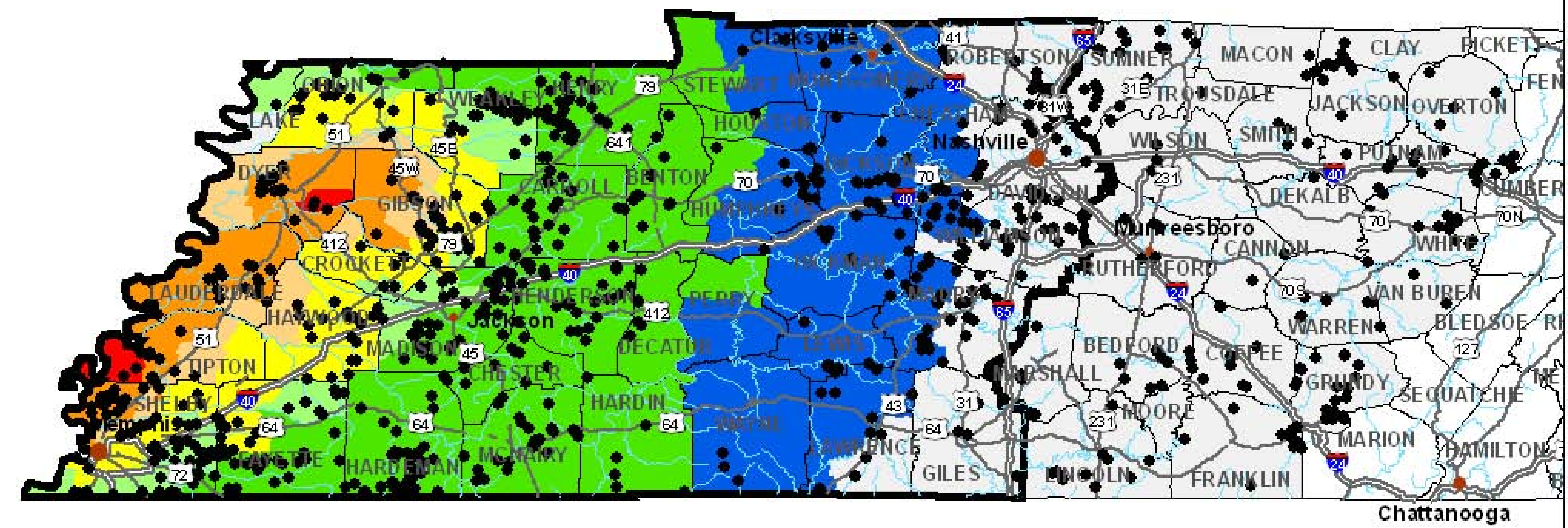
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

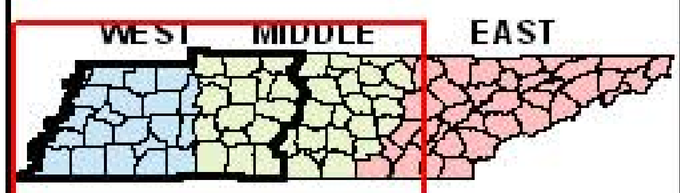
Dams - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Facilities	County	No. of Facilities	County	No. of Facilities
Benton	11	Hardin	7	`	24
Carroll	27	Haywood	20	Montgomery	6
Cheatham	5	Henderson	27	Obion	23
Chester	11	Henry	32	Perry	
Crockett	5	Hickman	11	Robertson	9
Davidson	23	Houston	3	Shelby	87
Decatur	6	Humphreys	12	Stewart	2
Dickson	22	Lake	1	Tipton	13
Dyer	22	Lauderdale	14	Wayne	3
Fayette	42	Lawrence	11	Weakley	25
Gibson	47	Lewis	6	Williamson	35
Giles	5	Madison	46		
Hardeman	41	Maury	32		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

- Dams

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

- Rivers
- Interstates
- Critical Counties
- US Routes

0 12.5 25 50 75
Miles

Mid-America Earthquake Center

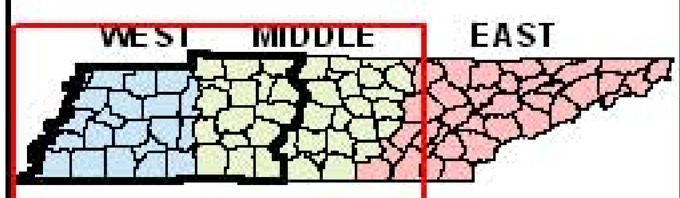
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Total Debris (Thousands of Tons) - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Tennessee - Critical Counties (37)

County	Brick/ Wood	Concrete/ Steel	Total Debris	County	Brick/ Wood	Concrete/ Steel	Total Debris
Benton	5	2	7	Humphreys	3	1	4
Carroll	81	84	165	Lake	25	28	53
Cheatham	0	0	0	Lauderdale	188	218	406
Chester	32	31	63	Lawrence	0	0	1
Crockett	92	120	212	Lewis	0	0	0
Davidson	10	2	12	McNairy	39	39	78
Decatur	13	9	21	Madison	310	361	671
Dickson	1	0	1	Maury	1	0	1
Dyer	341	427	767	Montgomery	2	0	2
Fayette	94	104	198	Obion	178	195	373
Gibson	313	346	659	Perry	2	1	3
Giles	0	0	0	Robertson	1	0	1
Hardeman	59	56	115	Shelby	5,001	6,207	11,209
Hardin	29	31	60	Stewart	8	5	12
Haywood	117	163	280	Tipton	357	411	768
Henderson	77	74	151	Wayne	1	0	1
Henry	70	73	143	Weakley	158	199	357
Hickman	0	0	0	Williamson	2	0	2
Houston	1	0	1				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Total Debris

Thousands of Tons

- 0 - 5
- 5 - 25
- 25 - 75
- 75 - 150
- 150 - 320
- Rivers
- Interstates
- Critical Counties
- US Routes

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

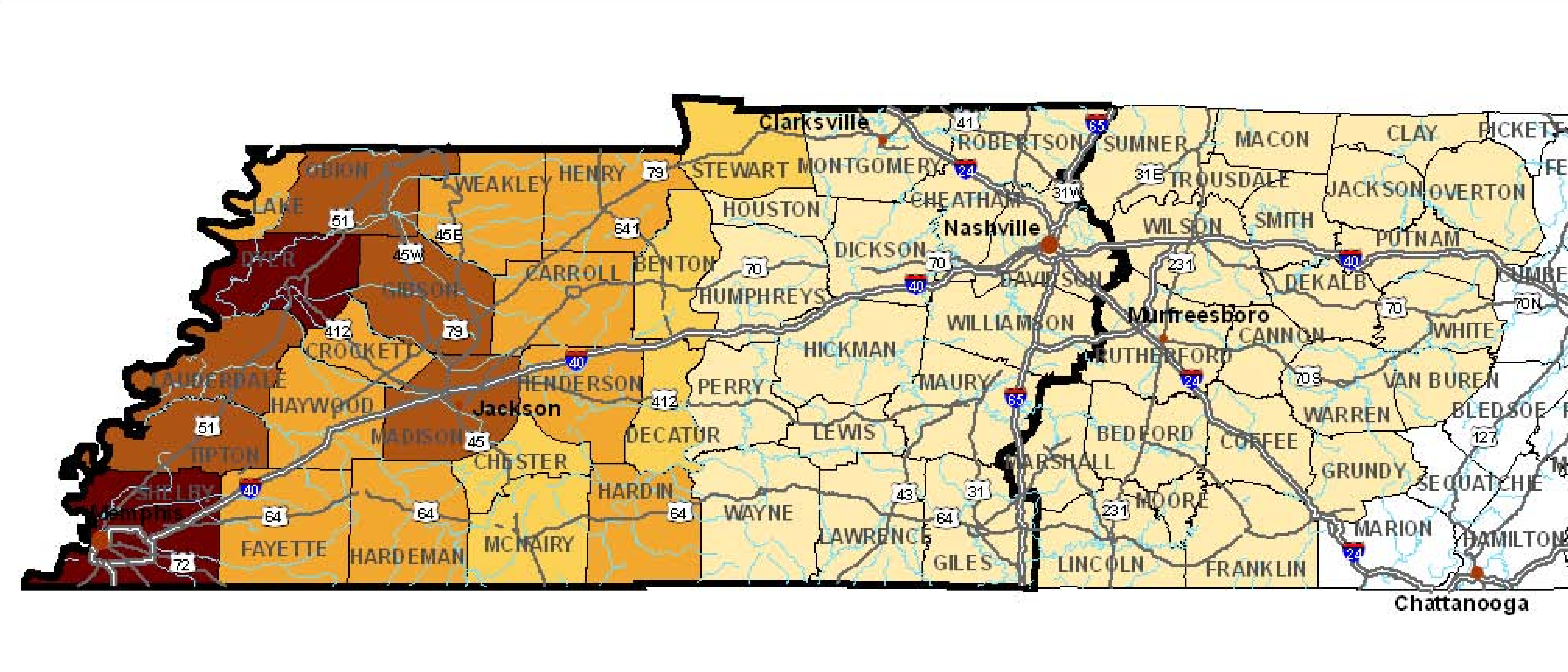
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

Displaced Population - New Madrid Seismic Zone: M7.7 Event

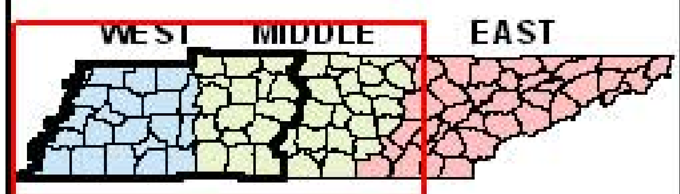
March 2008



State of Tennessee - Critical Counties (37)

County	Displaced Residences	Estimate of Displaced Population
Benton	13	31
Carroll	589	1475
Cheatham	0	0
Chester	173	475
Crockett	1085	2798
Davidson	1	2
Decatur	45	106
Dickson	0	0
Dyer	8682	21942
Fayette	1009	2776
Gibson	3888	9593
Giles	0	0
Hardeman	404	1206
Hardin	559	1370
Haywood	1214	3181
Henderson	833	2063
Henry	558	1334
Hickman	0	0
Houston	0	0

County	Displaced Residences	Estimate of Displaced Population
Humphreys	0	1
Lake	498	1642
Lauderdale	4675	13243
Lawrence	0	0
Lewis	0	0
McNairy	211	522
Madison	2956	7636
Maury	0	0
Montgomery	0	0
Obion	3168	7798
Perry	0	0
Robertson	0	0
Shelby	60772	161189
Stewart	33	83
Tipton	6443	18244
Wayne	0	0
Weakley	1636	4197
Williamson	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Displaced Population
- 0 - 25
- 26 - 1,000
- 1,001 - 5,000
- 5,001 - 20,000
- 20,001 - 162,000
- Rivers
- Interstates
- Critical Counties
- US Routes

Major Cities
- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

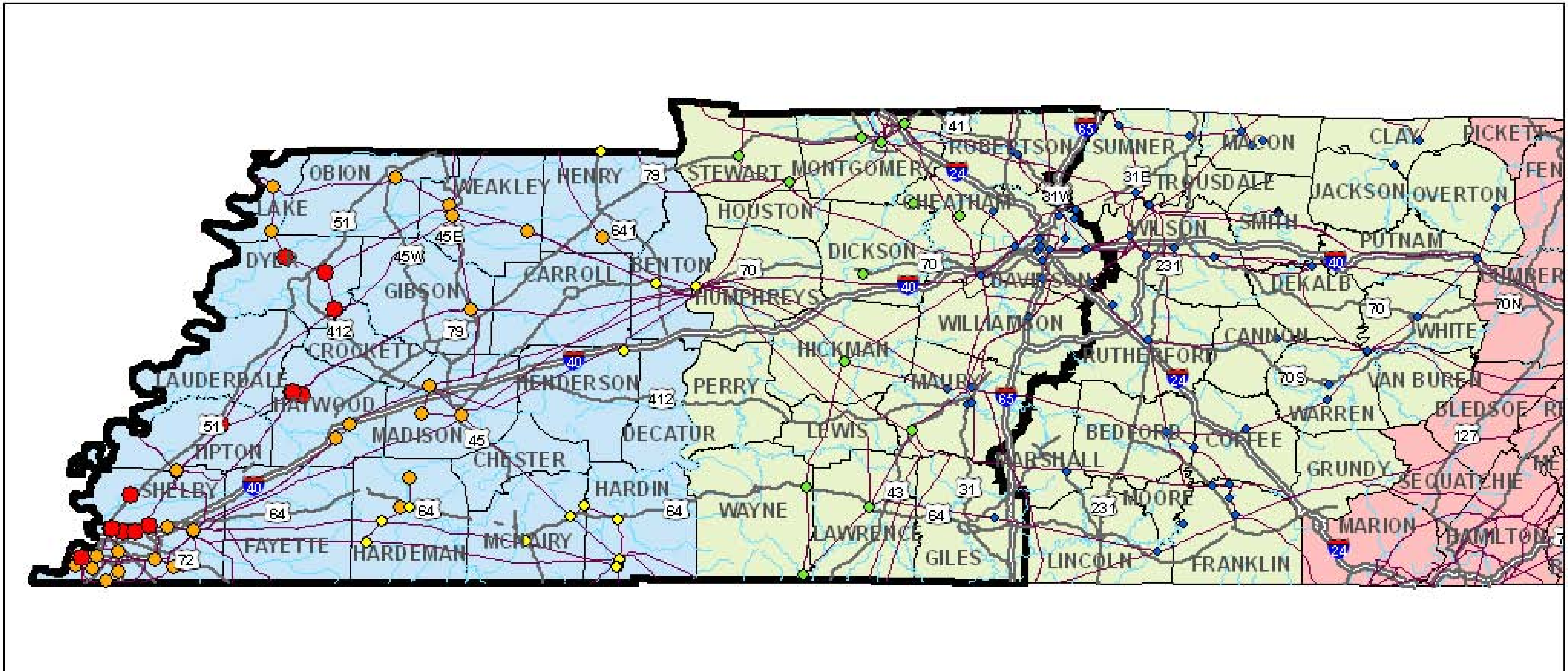
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

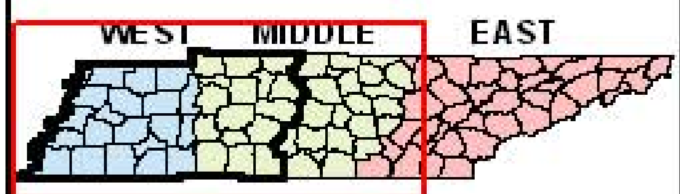
Electric Power Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	1	0	0
Carroll	0	0	0
Cheatham	3	0	0
Chester	0	0	0
Crockett	0	0	0
Davidson	33	0	0
Decatur	0	0	0
Dickson	2	0	0
Dyer	3	3	0
Fayette	0	0	0
Gibson	1	1	0
Giles	1	0	0
Hardeman	16	2	0
Hardin	7	0	0
Haywood	10	10	0
Henderson	1	0	0
Henry	2	1	0
Hickman	1	0	0
Houston	0	0	0
Humphreys	2	0	0
Lake	1	1	0
Lauderdale	0	0	0
Lawrence	2	0	0
Lewis	0	0	0
Madison	3	3	0
Maury	7	0	0
McNairy	3	0	0
Montgomery	5	0	0
Obion	2	2	0
Perry	0	0	0
Robertson	2	0	0
Shelby	32	32	0
Stewart	3	0	0
Tipton	1	1	0
Wayne	1	0	0
Weakley	7	7	0
Williamson	1	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Electric Power Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Electric Transmisson Lines

- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

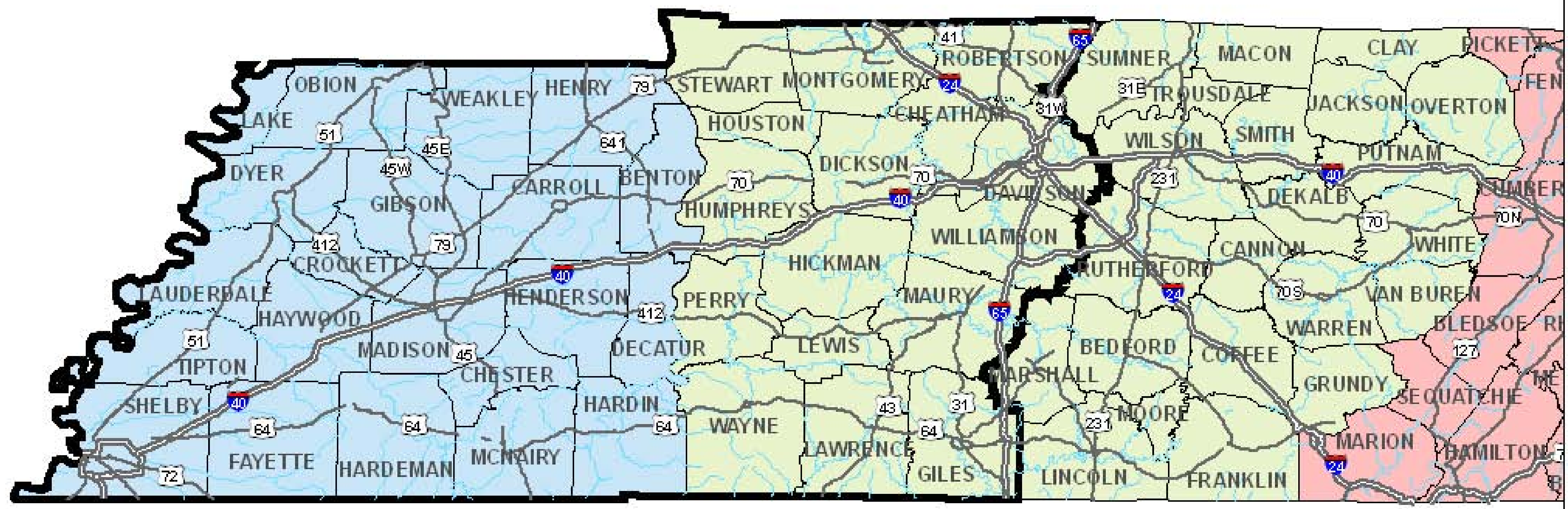
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

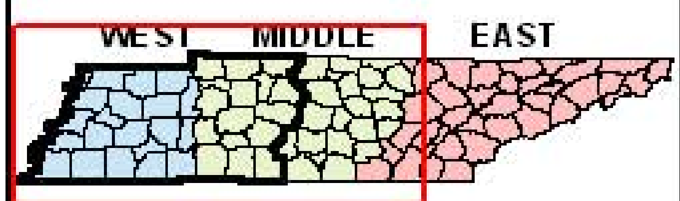
Emergency Operation Center Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	0	0	0	Humphreys	0	0	0
Carroll	0	0	0	Lake	0	0	0
Cheatham	0	0	0	Lauderdale	0	0	0
Chester	0	0	0	Lawrence	0	0	0
Crockett	0	0	0	Lewis	0	0	0
Davidson	0	0	0	McNairy	0	0	0
Decatur	0	0	0	Madison	0	0	0
Dickson	0	0	0	Maury	0	0	0
Dyer	0	0	0	Montgomery	0	0	0
Fayette	0	0	0	Obion	0	0	0
Gibson	0	0	0	Perry	0	0	0
Giles	0	0	0	Robertson	0	0	0
Hardeman	0	0	0	Shelby	0	0	0
Hardin	0	0	0	Stewart	0	0	0
Haywood	0	0	0	Tipton	0	0	0
Henderson	0	0	0	Wayne	0	0	0
Henry	0	0	0	Weakley	0	0	0
Hickman	0	0	0	Williamson	0	0	0
Houston	0	0	0				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Emergency Operation Centers

At Least Moderate Damage

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Rivers
- Interstates
- Critical Counties
- US Routes

- West Reg
- Middle Reg
- East Reg

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

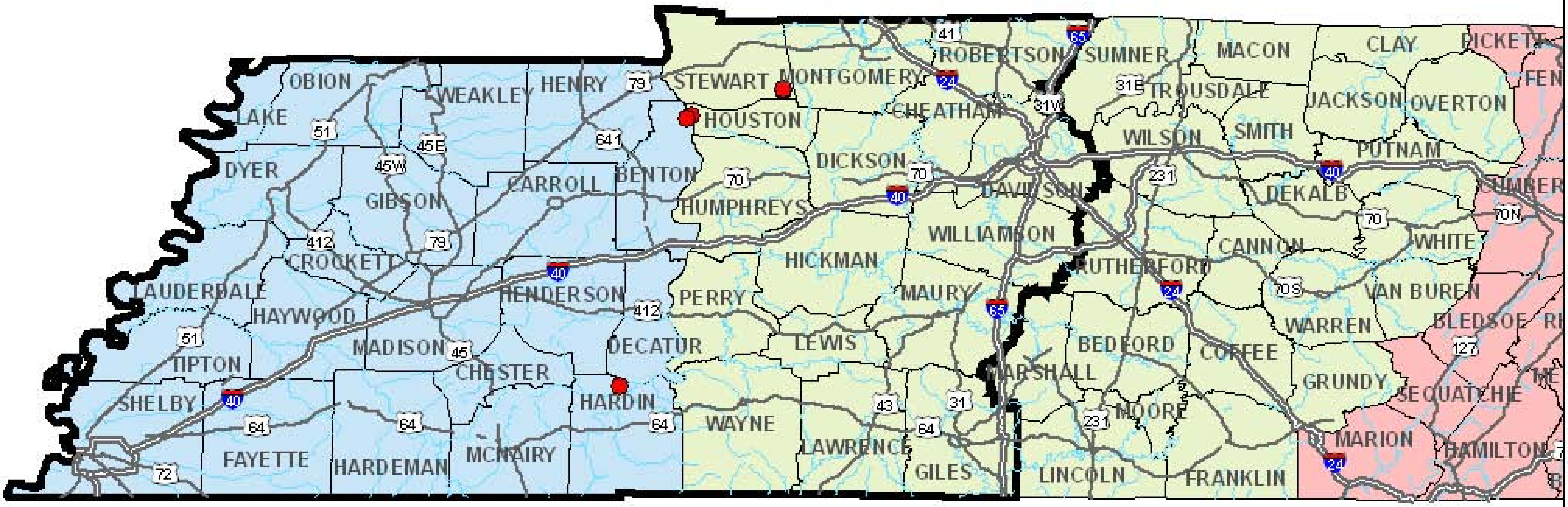
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

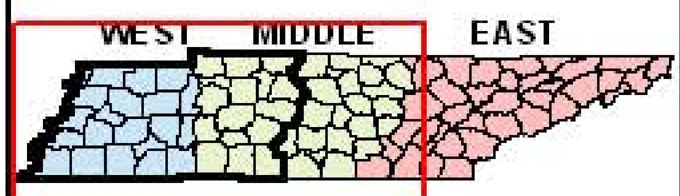
Ferry Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	1	1	1
Carroll	0	0	0
Cheatham	0	0	0
Chester	0	0	0
Crockett	0	0	0
Davidson	0	0	0
Decatur	0	0	0
Dickson	0	0	0
Dyer	0	0	0
Fayette	0	0	0
Gibson	0	0	0
Giles	0	0	0
Hardeman	0	0	0
Hardin	2	2	2
Haywood	0	0	0
Henderson	0	0	0
Henry	0	0	0
Hickman	0	0	0
Houston	1	1	1
Humphreys	0	0	0
Lake	0	0	0
Lauderdale	0	0	0
Lawrence	0	0	0
Lewis	0	0	0
Madison	0	0	0
Maury	0	0	0
McNairy	0	0	0
Montgomery	0	0	0
Obion	0	0	0
Perry	0	0	0
Robertson	0	0	0
Shelby	0	0	0
Stewart	2	2	2
Tipton	0	0	0
Wayne	0	0	0
Weakley	0	0	0
Williamson	0	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Ferry Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Rivers
Interstates
Critical Counties
US Routes

West Region
Middle Region
East Region

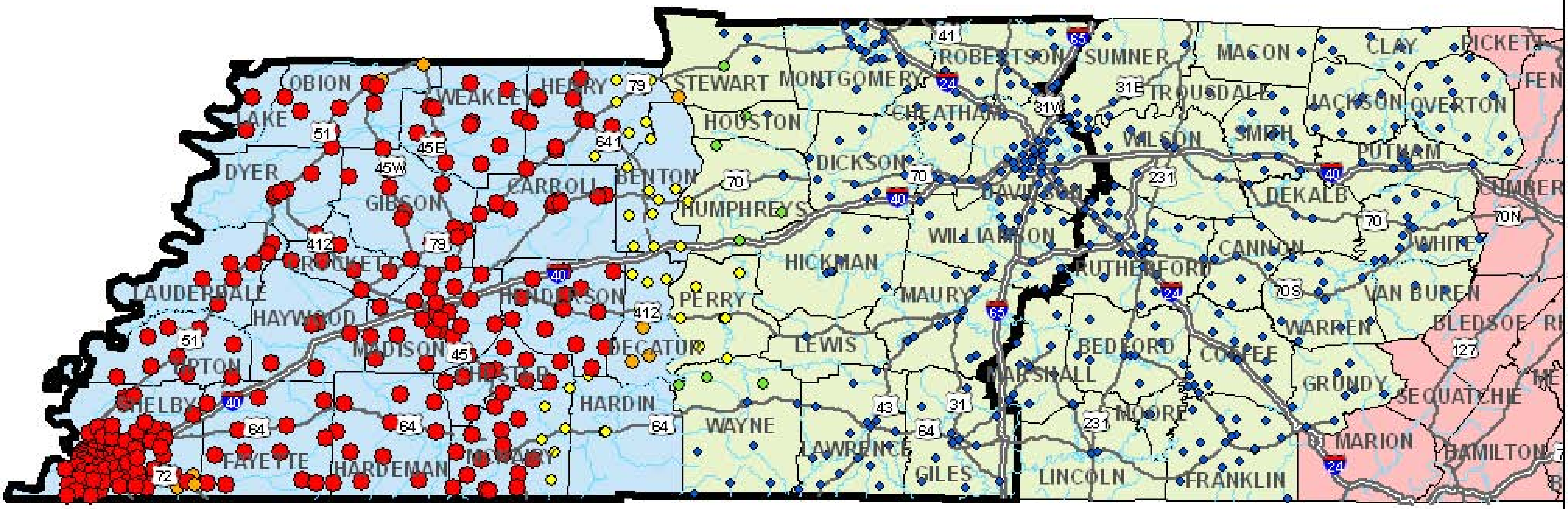
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Fire Station Damage - New Madrid Seismic Zone: M7.7 Event

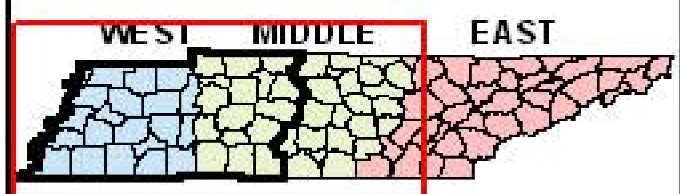
March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	10	0	0
Carroll	11	11	0
Cheatham	11	0	0
Chester	10	10	0
Crockett	7	7	7
Davidson	37	0	0
Decatur	8	3	0
Dickson	12	0	0
Dyer	6	6	6
Fayette	13	13	4
Gibson	12	12	9
Giles	12	0	0
Hardeman	12	12	0
Hardin	3	0	0
Haywood	5	5	5
Henderson	14	14	0
Henry	17	10	0
Hickman	7	0	0
Houston	2	0	0

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Humphreys	9	0	0
Lake	2	2	1
Lauderdale	7	7	7
Lawrence	18	0	0
Lewis	1	0	0
McNairy	22	16	0
Madison	22	22	0
Maury	12	0	0
Montgomery	17	0	0
Obion	10	10	6
Perry	7	0	0
Robertson	13	0	0
Shelby	73	73	56
Stewart	5	1	0
Tipton	10	10	10
Wayne	10	0	0
Weakley	12	12	6
Williamson	22	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Fire Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- West Region
- Middle Region
- East Region

- Rivers
- Interstates
- Critical Counties
- US Routes

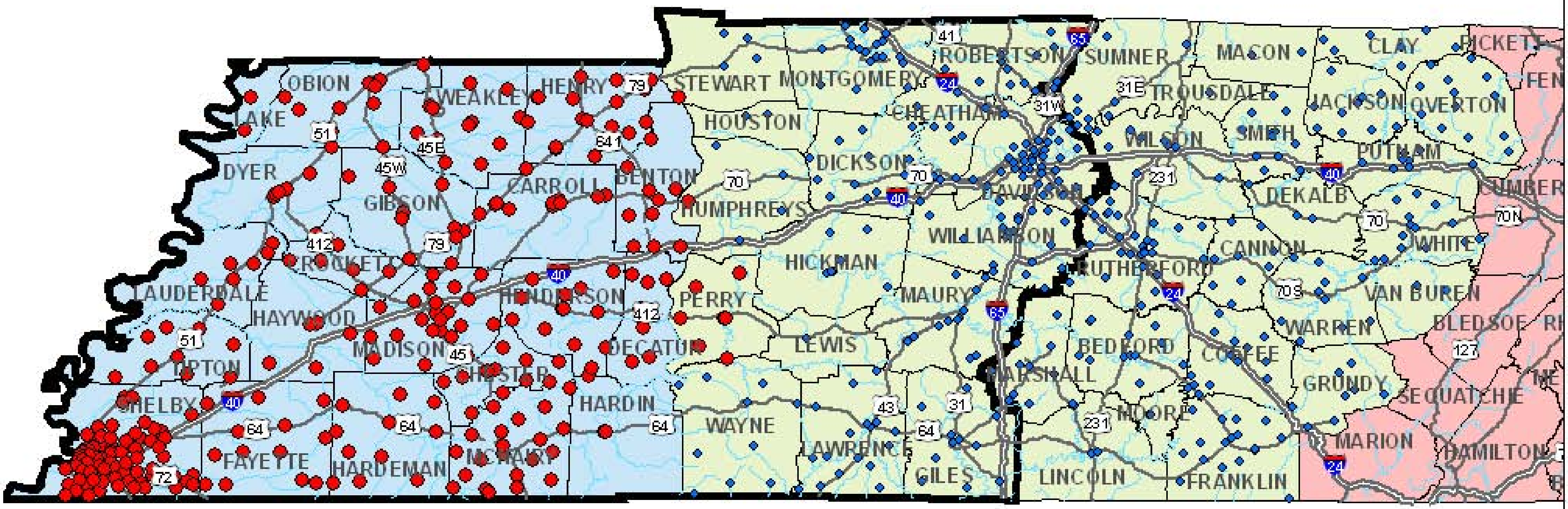
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

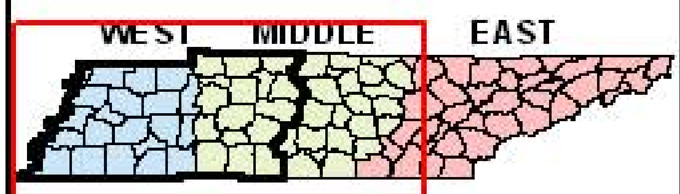
Fire Station Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Functional Facilities	Total No. of Facilities	County	No. of Functional Facilities	Total No. of Facilities
Benton	0	10	Humphreys	8	9
Carroll	0	11	Lake	0	2
Cheatham	11	11	Lauderdale	0	7
Chester	0	10	Lawrence	18	18
Crockett	0	7	Lewis	1	1
Davidson	37	37	Madison	0	22
Decatur	0	8	Maury	12	12
Dickson	12	12	McNairy	0	22
Dyer	0	6	Montgomery	17	17
Fayette	0	13	Obion	0	10
Gibson	0	12	Perry	0	7
Giles	12	12	Robertson	13	13
Hardeman	0	12	Shelby	0	73
Hardin	0	3	Stewart	4	5
Haywood	0	5	Tipton	0	10
Henderson	0	14	Wayne	10	10
Henry	0	17	Weakley	0	12
Hickman	7	7	Williamson	22	22
Houston	2	2			



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Fire Station Functionality

Day 1

- Non-Functional
- Functional
- Rivers
- Interstates
- Critical Counties
- US Routes

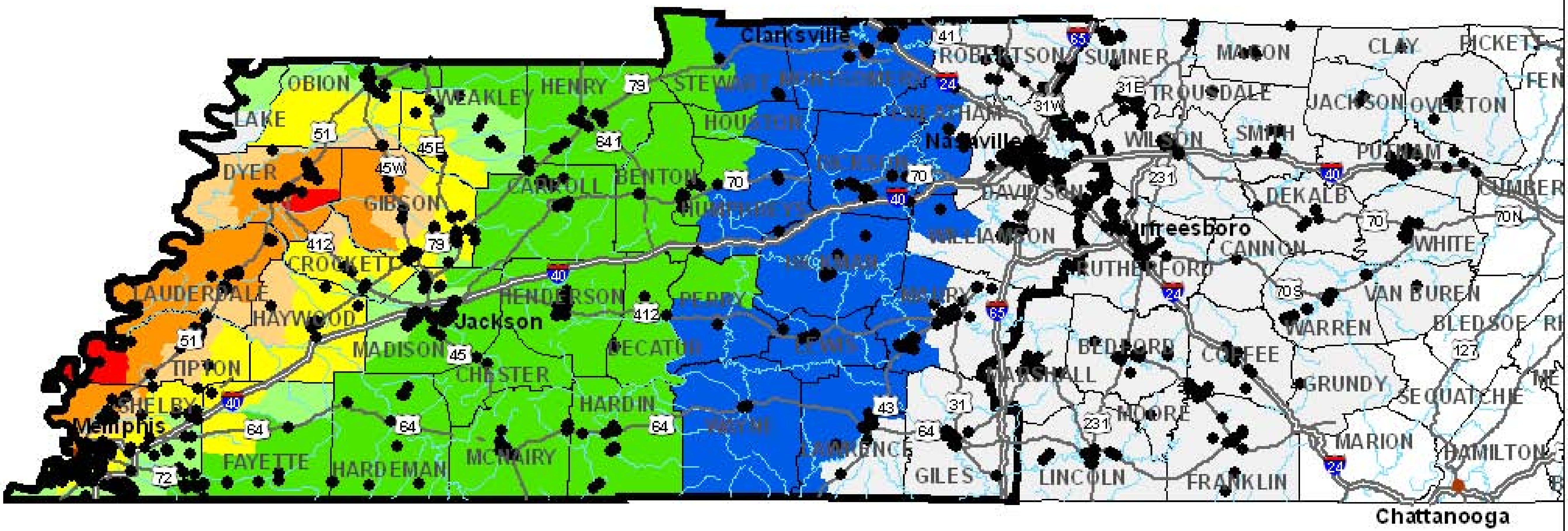
West Region
Middle Region
East Region

0 12.5 25 50 75
Miles

Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

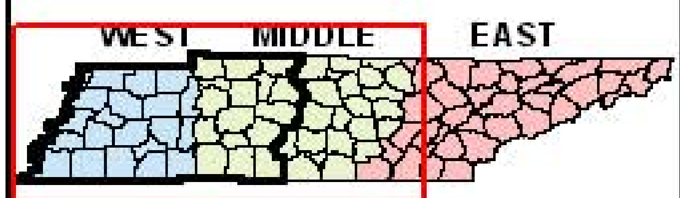
Hazardous Materials Facilities - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Facilities	County	No. of Facilities	County	No. of Facilities
Benton	2	Hardin	30	``	31
Carroll	38	Haywood	18	Montgomery	38
Cheatham	31	Henderson	27	Obion	28
Chester	6	Henry	30	Perry	1
Crockett	5	Hickman	12	Robertson	33
Davidson	241	Houston		Shelby	549
Decatur	6	Humphreys	68	Stewart	41
Dickson	47	Lake	3	Tipton	19
Dyer	44	Lauderdale	51	Wayne	3
Fayette	31	Lawrence	26	Weakley	13
Gibson	51	Lewis	10	Williamson	36
Giles	27	Madison	86		
Hardeman	25	Maury	78		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

- Hazardous Materials Facilities

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

- Rivers
- Interstates
- Critical Counties
- US Routes

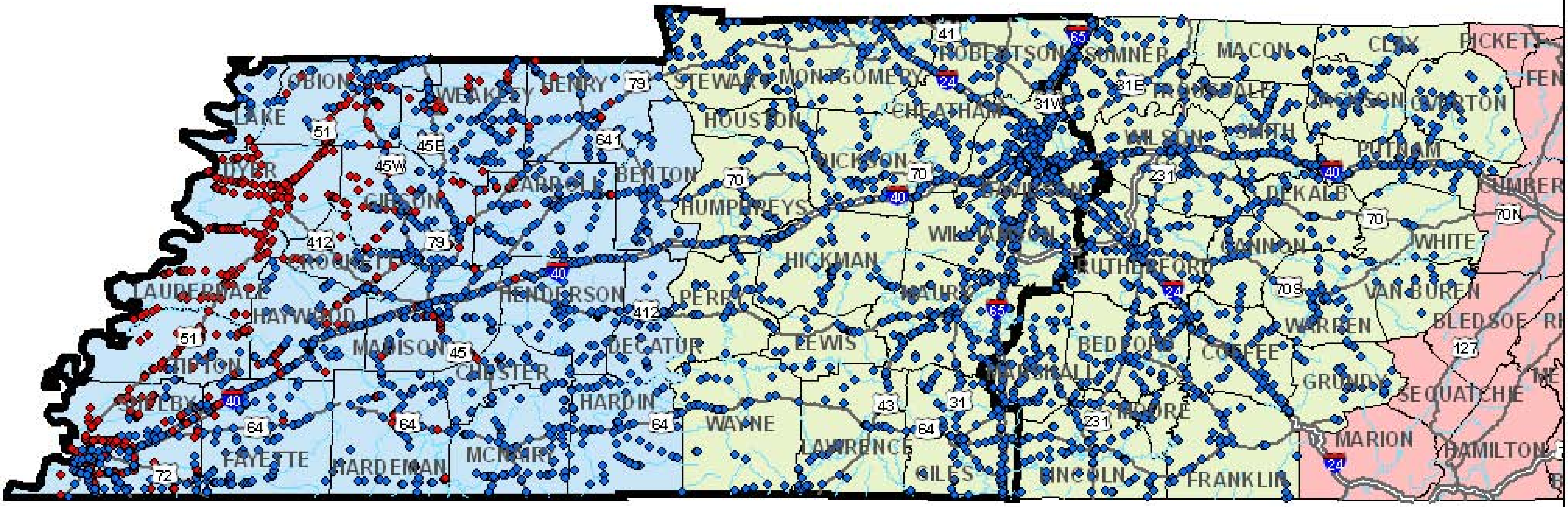
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

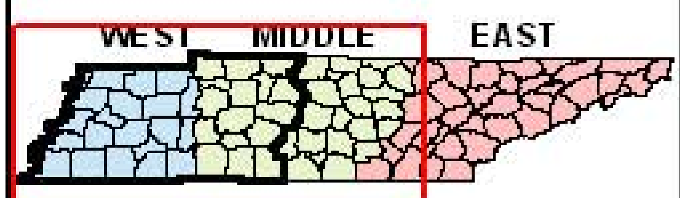
Highway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Functional Facilities	Total No. of Facilities
Benton	52	52
Carroll	103	122
Cheatham	38	38
Chester	36	41
Crockett	27	56
Davidson	521	521
Decatur	39	39
Dickson	68	68
Dyer	0	121
Fayette	107	129
Gibson	89	141
Giles	117	117
Hardeman	66	90
Hardin	58	58
Haywood	77	133
Henderson	87	89
Henry	75	86
Hickman	71	71
Houston	22	22
Humphreys	66	66
Lake	12	14
Lauderdale	0	94
Lawrence	43	43
Lewis	21	21
McNairy	88	90
Madison	117	145
Maury	147	147
Montgomery	80	80
Obion	81	144
Perry	36	36
Robertson	79	79
Shelby	168	436
Stewart	70	70
Tipton	11	54
Wayne	44	44
Weakley	94	131
Williamson	127	127



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Highway Bridge Functionality

Day 1

- Non-Functional
- Functional
- Rivers
- Interstates
- Critical Counties
- US Routes

- West Region
- Middle Region
- East Region

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

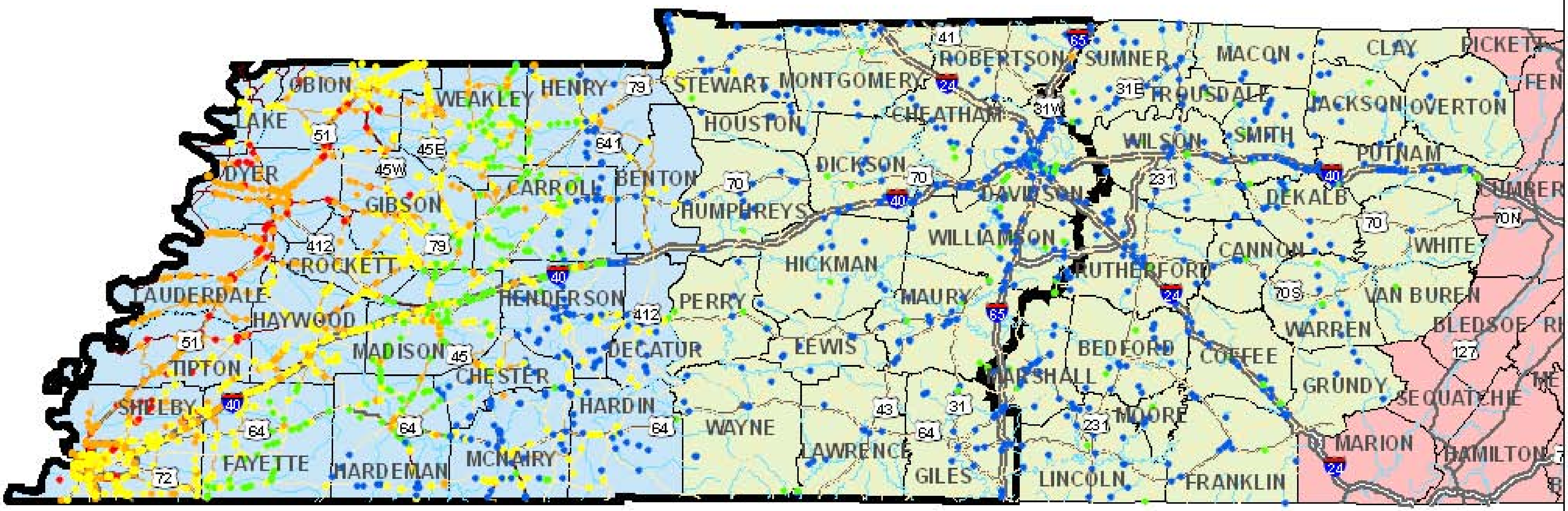
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

Highway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

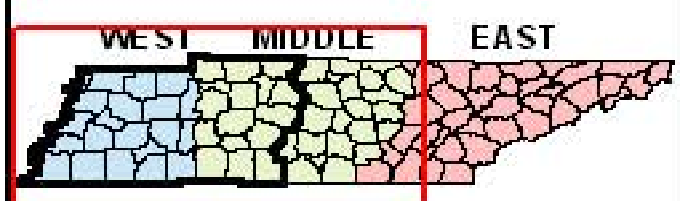
March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	52	0	0
Carroll	122	19	0
Cheatham	38	0	0
Chester	41	7	0
Crockett	56	29	4
Davidson	521	0	0
Decatur	39	0	0
Dickson	68	0	0
Dyer	121	121	65
Fayette	129	22	0
Gibson	141	51	15
Giles	117	0	0
Hardeman	90	26	0
Hardin	58	0	0
Haywood	133	56	1
Henderson	89	4	0
Henry	86	13	0
Hickman	71	0	0
Houston	22	0	0

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Humphreys	66	0	0
Lake	14	1	1
Lauderdale	94	94	45
Lawrence	43	0	0
Lewis	21	0	0
McNairy	90	3	0
Madison	145	30	0
Maury	147	0	0
Montgomery	80	0	0
Obion	144	59	26
Perry	36	0	0
Robertson	79	0	0
Shelby	436	262	155
Stewart	70	0	0
Tipton	54	43	17
Wayne	44	0	0
Weakley	131	37	1
Williamson	127	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Highway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Rivers
Interstates
US Routes

Highway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood

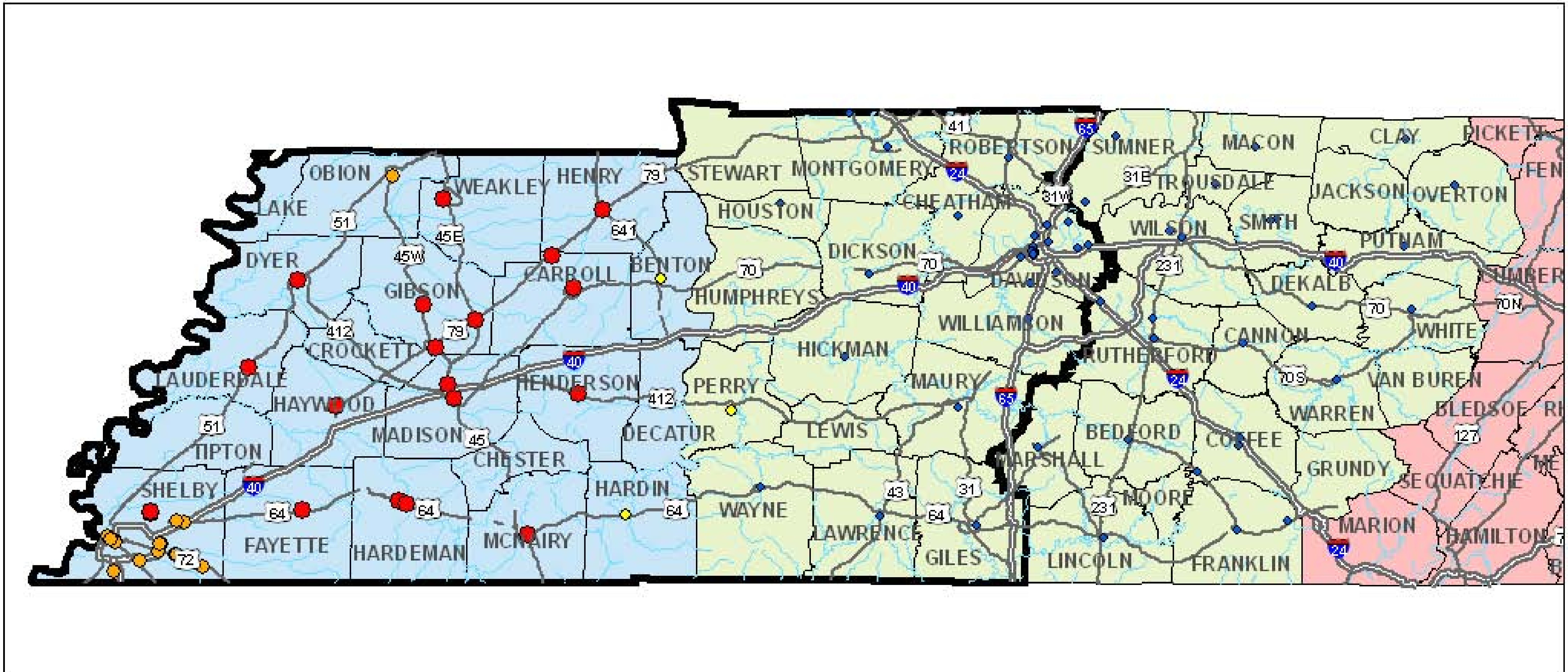
West Region
Middle Region
East Region

0 12.5 25 50 75
Miles

Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Hospital Damage - New Madrid Seismic Zone: M7.7 Event

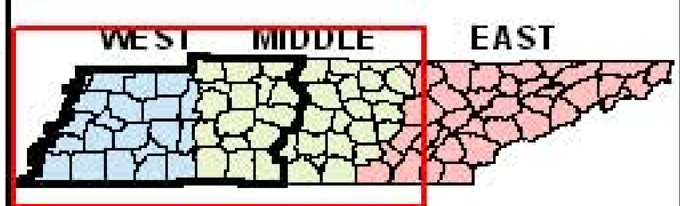
March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	1	0	0
Carroll	2	2	0
Cheatham	1	0	0
Chester	0	0	0
Crockett	0	0	0
Davidson	20	0	0
Decatur	1	0	0
Dickson	1	0	0
Dyer	1	1	1
Fayette	1	1	0
Gibson	3	3	2
Giles	1	0	0
Hardeman	2	2	0
Hardin	1	0	0
Haywood	1	1	1
Henderson	1	1	0
Henry	1	1	0
Hickman	1	0	0
Houston	1	0	0

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Humphreys	1	0	0
Lake	0	0	0
Lauderdale	1	1	1
Lawrence	1	0	0
Lewis	0	0	0
Madison	3	3	0
Maury	1	0	0
McNairy	1	1	0
Montgomery	2	0	0
Obion	1	1	0
Perry	1	0	0
Robertson	1	0	0
Shelby	22	22	0
Stewart	0	0	0
Tipton	1	1	1
Wayne	1	0	0
Weakley	2	2	2
Williamson	2	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Hospital Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Rivers
Interstates
Critical Counties
US Routes

West Region
Middle Region
East Region

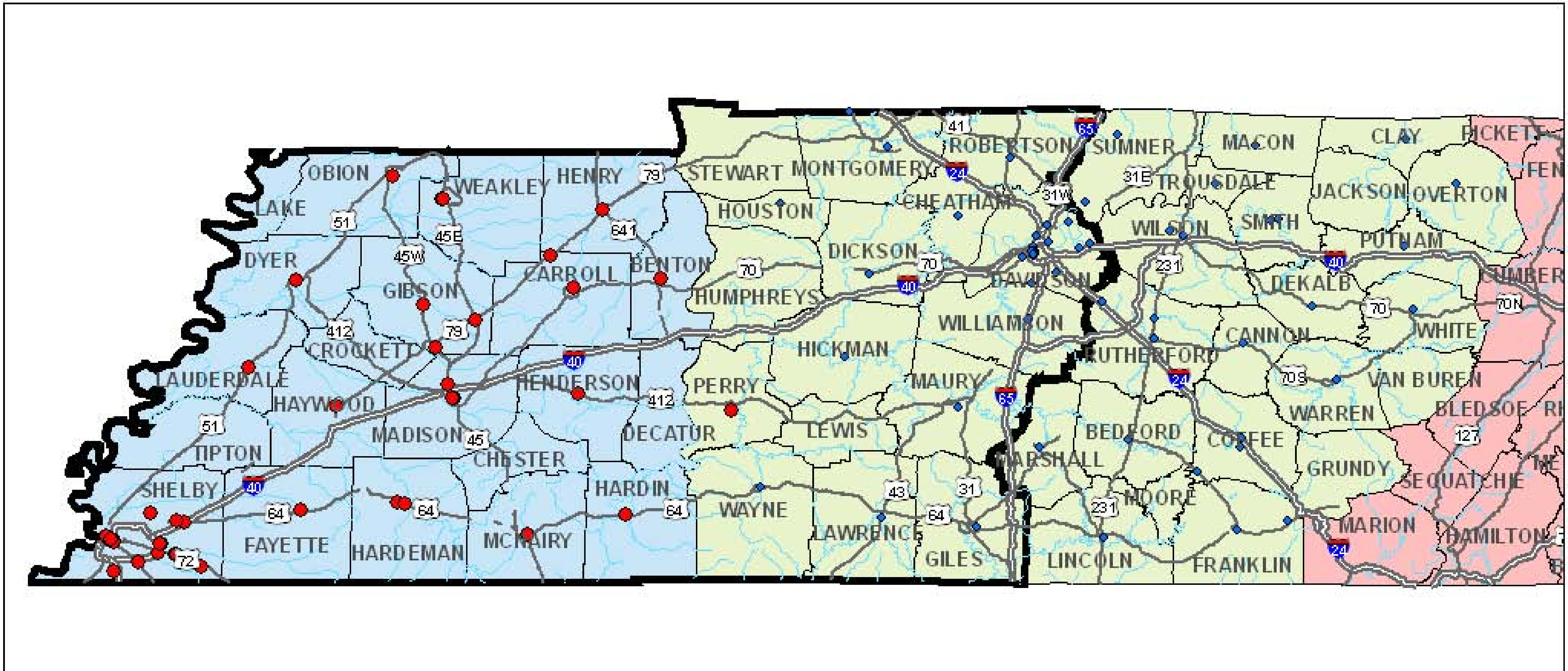
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

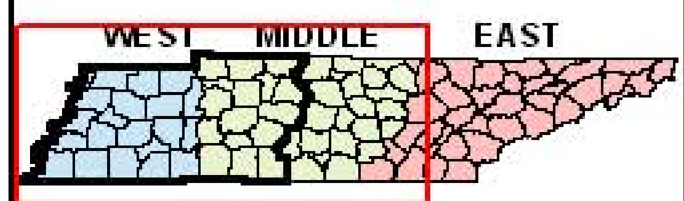
Hospital Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Functional Facilities	Total No. of Facilities	County	No. of Functional Facilities	Total No. of Facilities
Benton	0	1	Humphreys	0	1
Carroll	0	2	Lake	0	0
Cheatham	1	1	Lauderdale	0	1
Chester	0	0	Lawrence	1	1
Crockett	0	0	Lewis	0	0
Davidson	20	20	Madison	0	3
Decatur	0	1	Maury	1	1
Dickson	1	1	McNairy	0	1
Dyer	0	1	Montgomery	2	2
Fayette	0	1	Obion	0	1
Gibson	0	3	Perry	0	1
Giles	1	1	Robertson	1	1
Hardeman	0	2	Shelby	0	22
Hardin	0	1	Stewart	0	0
Haywood	0	1	Tipton	0	1
Henderson	0	1	Wayne	1	1
Henry	0	1	Weakley	0	2
Hickman	1	1	Williamson	2	2
Houston	1	1			



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Hospital Functionality

Day 1

- Non-Functional
- Functional
- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

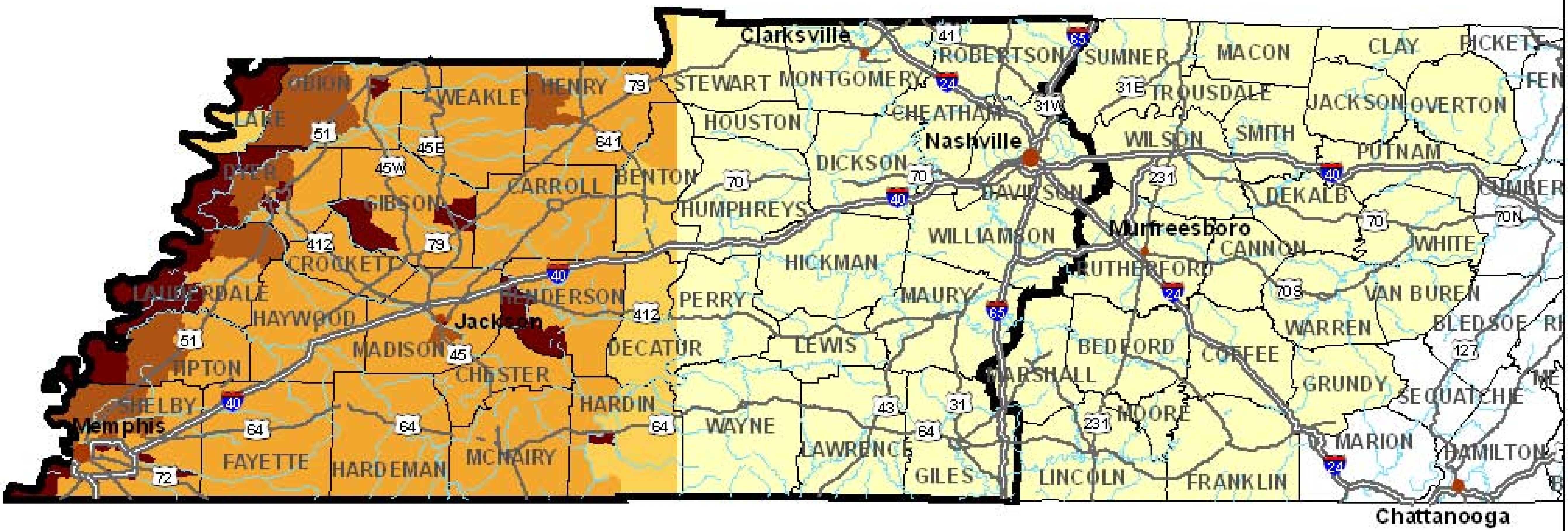
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

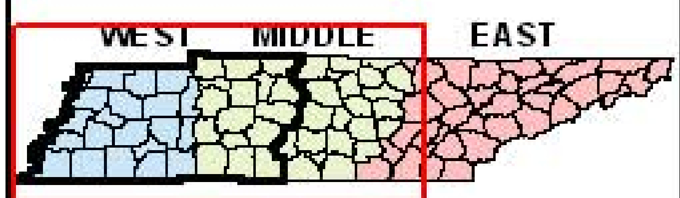
Liquefaction Susceptibility - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Minimum Susceptibility	Maximum Susceptibility	County	Minimum Susceptibility	Maximum Susceptibility
Benton	Unknown	Low	Humphreys	Unknown	None
Carroll	None	Very High	Lake	None	Very High
Cheatham	Unknown	Unknown	Lauderdale	None	Very High
Chester	Low	Very High	Lawrence	Unknown	Unknown
Crockett	Low	Very High	Lewis	Unknown	Unknown
Davidson	Unknown	Unknown	Madison	Low	Very High
Decatur	Unknown	Low	Maury	Unknown	Unknown
Dickson	Unknown	Unknown	McNairy	Unknown	Low
Dyer	None	Very High	Montgomery	Unknown	Unknown
Fayette	None	Low	Obion	None	Very High
Gibson	Low	Very High	Perry	Unknown	None
Giles	Unknown	Unknown	Robertson	Unknown	Unknown
Hardeman	Unknown	Low	Shelby	None	Very High
Hardin	Unknown	Very High	Stewart	Unknown	Low
Haywood	Low	Moderate	Tipton	None	Very High
Henderson	None	Very High	Wayne	Unknown	None
Henry	Unknown	Moderate	Weakley	None	Moderate
Hickman	Unknown	Unknown	Williamson	Unknown	Unknown
Houston	Unknown	Unknown			



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Liquefaction Susceptibility

- Unknown
- None
- Low
- Moderate
- Very High
- Rivers
- Interstates
- Critical Counties
- US Routes

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

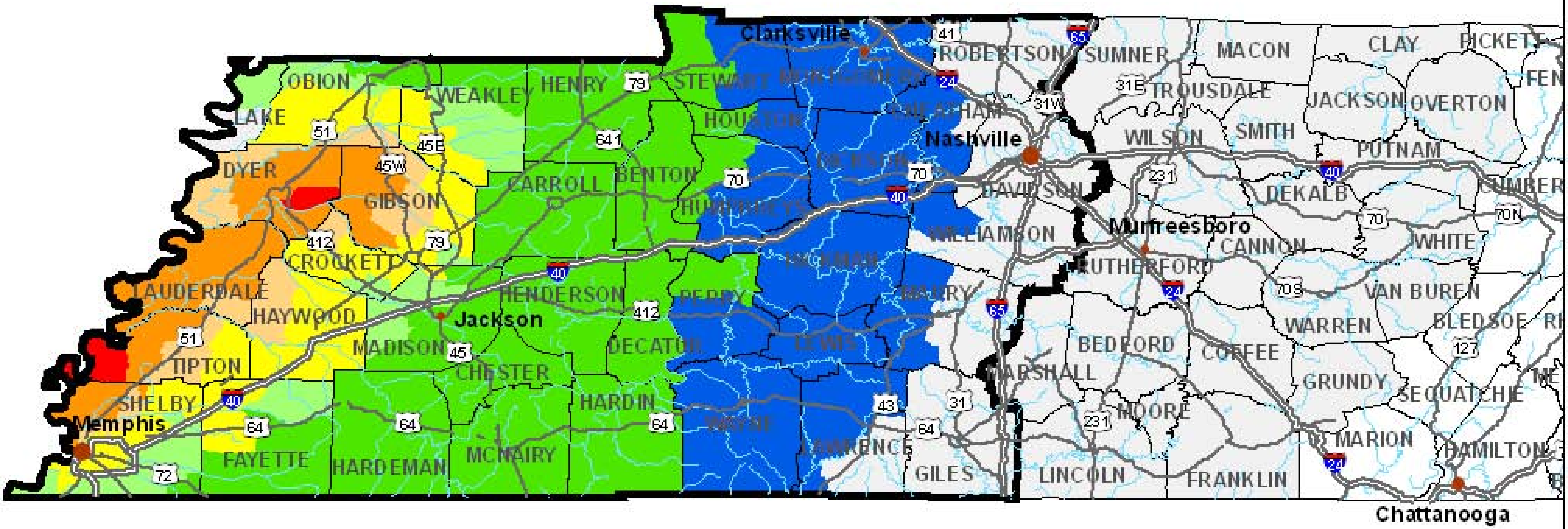
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

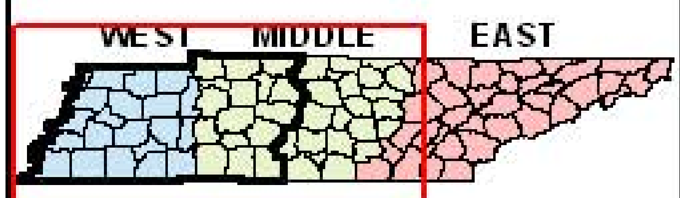
Modified Mercalli Intensity - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Max. MMI	County	Max. MMI	County	Max. MMI
Benton	VII	Hardin	VII	Maury	VI
Carroll	IX	Haywood	XI	Montgomery	VI
Cheatham	VI	Henderson	VII	Obion	XI
Chester	VII	Henry	VIII	Perry	VII
Crockett	XI	Hickman	VII	Robertson	VI
Davidson	VI	Houston	VII	Shelby	XII
Decatur	VII	Humphreys	VII	Stewart	VII
Dickson	VI	Lake	X	Tipton	XII
Dyer	XII	Lauderdale	XI	Wayne	VII
Fayette	IX	Lawrence	VI	Weakley	X
Gibson	XII	Lewis	VI	Williamson	VI
Giles	VI	McNairy	VII		
Hardeman	IX	Madison	IX		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Modified Mercalli Intensity

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

- Rivers
- Interstates
- Critical Counties
- US Routes

0 12.5 25 50 75

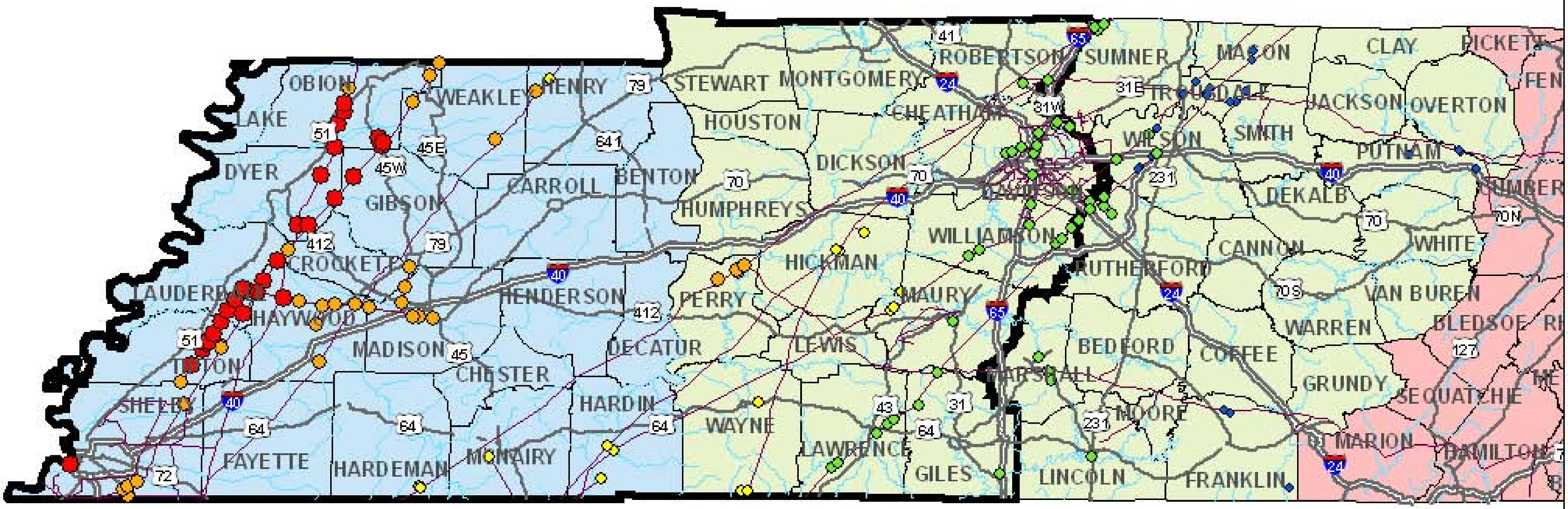
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

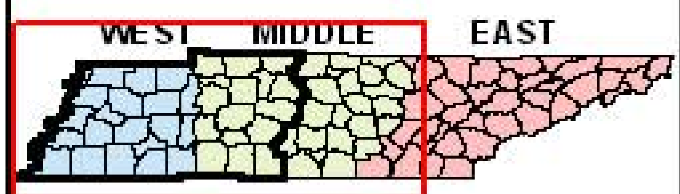
Natural Gas Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	0	0	0	Humphreys	0	0	0
Carroll	0	0	0	Lake	0	0	0
Cheatham	0	0	0	Lauderdale	6	6	0
Chester	0	0	0	Lawrence	5	0	0
Crockett	2	2	0	Lewis	0	0	0
Davidson	13	0	0	Madison	6	6	0
Decatur	0	0	0	Maury	6	0	0
Dickson	0	0	0	McNairy	1	0	0
Dyer	6	6	1	Montgomery	0	0	0
Fayette	0	0	0	Obion	8	8	0
Gibson	1	1	0	Perry	4	0	0
Giles	3	0	0	Robertson	2	0	0
Hardeman	2	0	0	Shelby	7	7	0
Hardin	4	0	0	Stewart	0	0	0
Haywood	9	9	0	Tipton	8	8	0
Henderson	0	0	0	Wayne	3	0	0
Henry	3	2	0	Weakley	4	4	0
Hickman	3	0	0	Williamson	15	0	0
Houston	0	0	0				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Natural Gas Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Major Natural Gas Lines

- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

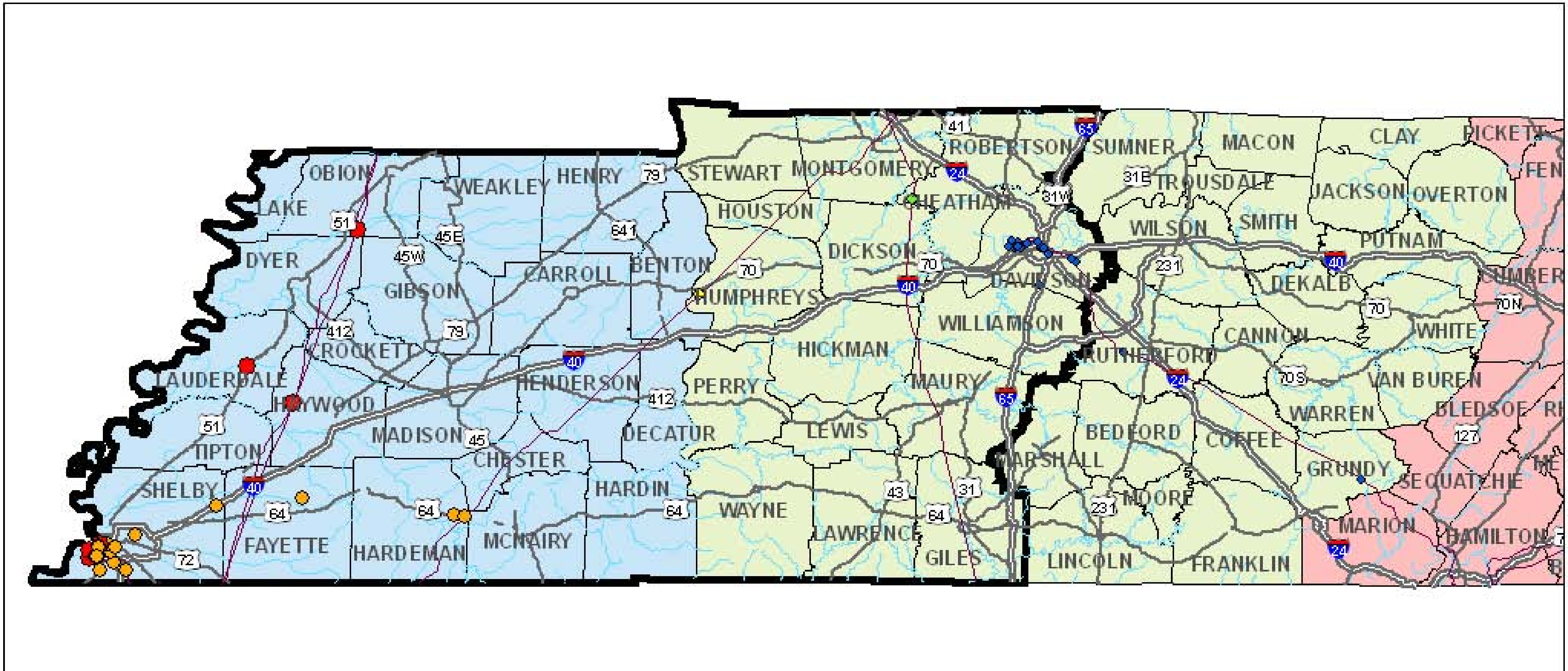
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

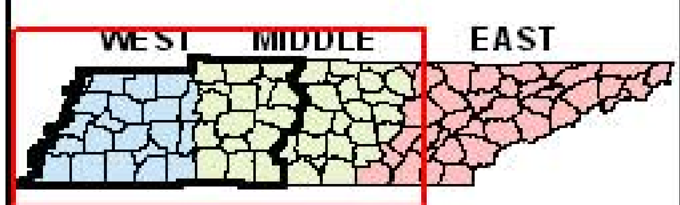
Oil Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	0	0	0
Carroll	0	0	0
Cheatham	1	0	0
Chester	0	0	0
Crockett	0	0	0
Davidson	30	0	0
Decatur	0	0	0
Dickson	0	0	0
Dyer	0	0	0
Fayette	1	1	0
Gibson	0	0	0
Giles	0	0	0
Hardeman	2	2	0
Hardin	0	0	0
Haywood	1	1	0
Henderson	0	0	0
Henry	0	0	0
Hickman	0	0	0
Houston	0	0	0
Humphreys	1	0	0
Lake	0	0	0
Lauderdale	1	1	0
Lawrence	0	0	0
Lewis	0	0	0
Madison	0	0	0
Maury	0	0	0
McNairy	0	0	0
Montgomery	0	0	0
Obion	1	1	0
Perry	0	0	0
Robertson	0	0	0
Shelby	26	26	0
Stewart	0	0	0
Tipton	0	0	0
Wayne	0	0	0
Weakley	0	0	0
Williamson	1	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Oil Facility Damage

At Least Moderate

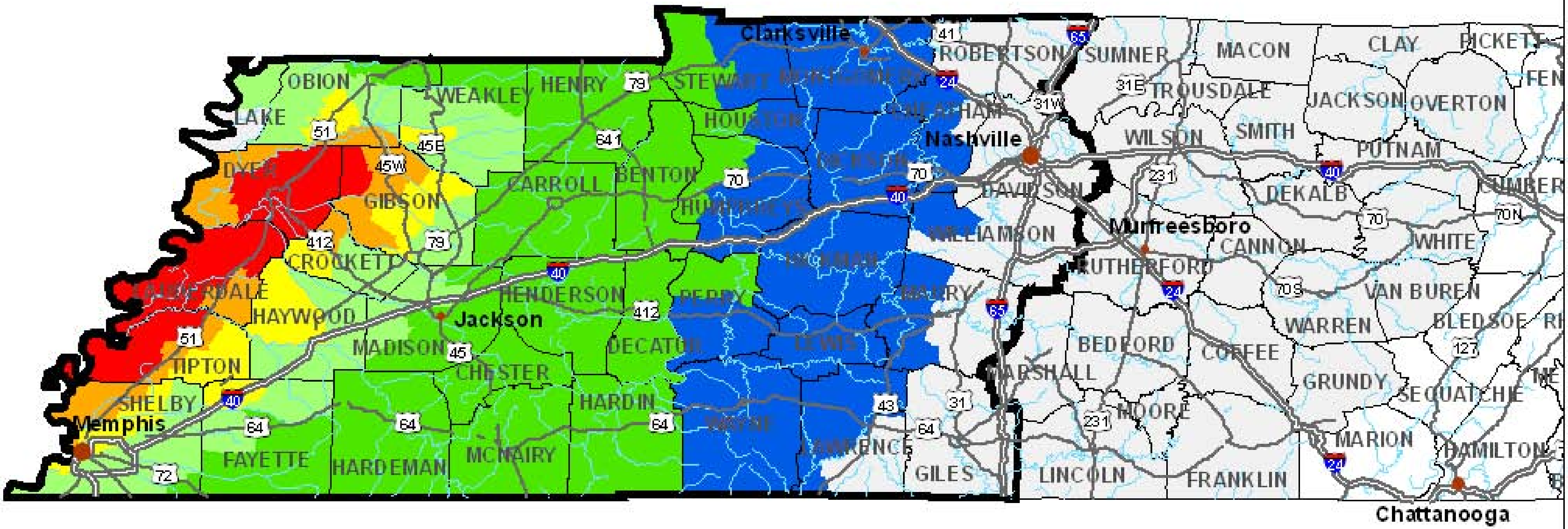
- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- Major Oil Lines
- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75
Miles

Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

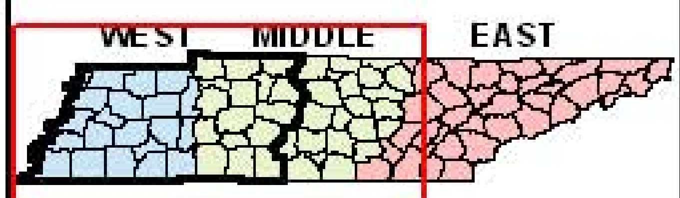
Peak Ground Acceleration - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Min. PGA	Max. PGA	County	Min. PGA	Max. PGA	County	Min. PGA	Max. PGA
Benton	0.15	0.25	Hardin	0.15	0.25	Maury	0.07	0.15
Carroll	0.25	0.64	Haywood	0.34	1.14	Montgomery	0.07	0.15
Cheatham	0.07	0.15	Henderson	0.25	0.34	Obion	0.00	1.04
Chester	0.25	0.34	Henry	0.25	0.44	Perry	0.15	0.25
Crockett	0.44	1.14	Hickman	0.07	0.25	Robertson	0.07	0.15
Davidson	0.05	0.15	Houston	0.15	0.25	Shelby	0.34	1.23
Decatur	0.15	0.25	Humphreys	0.15	0.25	Stewart	0.15	0.25
Dickson	0.15	0.15	Lake	0.00	0.85	Tipton	0.55	1.23
Dyer	0.00	1.23	Lauderdale	0.64	1.14	Wayne	0.15	0.25
Fayette	0.25	0.64	Lawrence	0.07	0.15	Weakley	0.25	0.85
Gibson	0.34	1.23	Lewis	0.15	0.15	Williamson	0.07	0.15
Giles	0.07	0.15	McNairy	0.25	0.34			
Hardeman	0.25	0.55	Madison	0.25	0.64			



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

PGA (g)

- 0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.0
- 1.0 - 1.23

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000
- Rivers
- Interstates
- Critical Counties
- US Routes

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

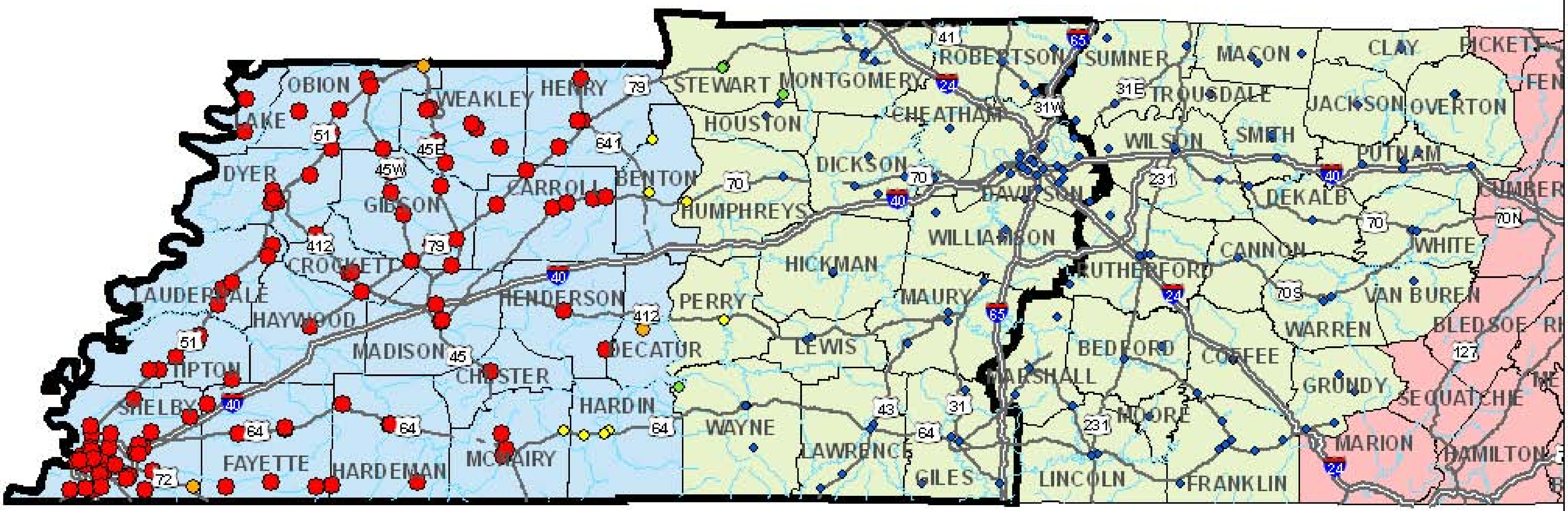
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

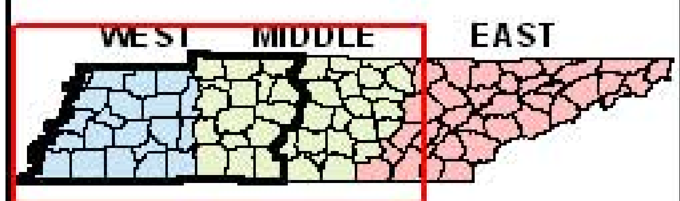
Police Station Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	3	0	0
Carroll	6	6	0
Cheatham	3	0	0
Chester	2	2	0
Crockett	4	4	4
Davidson	23	0	0
Decatur	3	2	0
Dickson	4	0	0
Dyer	7	7	7
Fayette	7	7	2
Gibson	9	9	7
Giles	5	0	0
Hardeman	5	5	0
Hardin	3	0	0
Haywood	2	2	2
Henderson	3	3	0
Henry	4	4	0
Hickman	2	0	0
Houston	2	0	0
Humphreys	4	0	0
Lake	3	3	1
Lauderdale	5	5	5
Lawrence	6	0	0
Lewis	2	0	0
Madison	3	3	0
Maury	4	0	0
Mc Nairy	4	3	0
Montgomery	5	0	0
Obion	7	7	4
Perry	1	0	0
Robertson	5	0	0
Shelby	39	39	36
Stewart	3	0	0
Tipton	6	6	6
Wayne	4	0	0
Weakley	7	7	4
Williamson	4	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Police Station Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

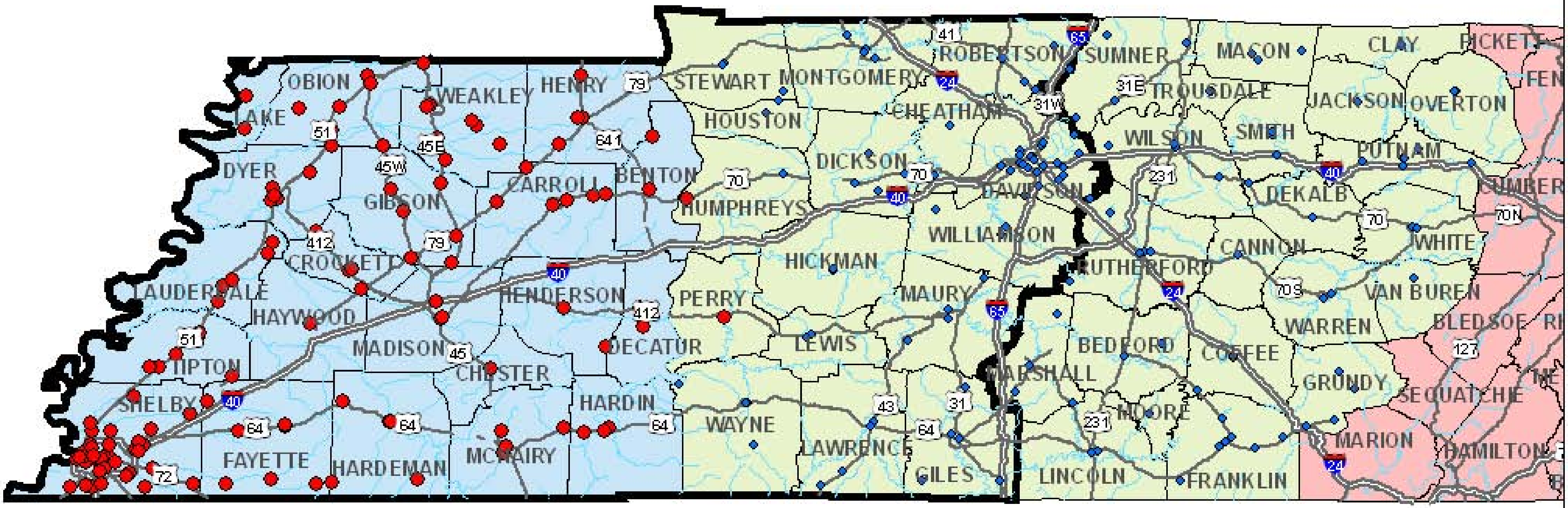
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

Police Station Functionality - New Madrid Seismic Zone: M7.7 Event

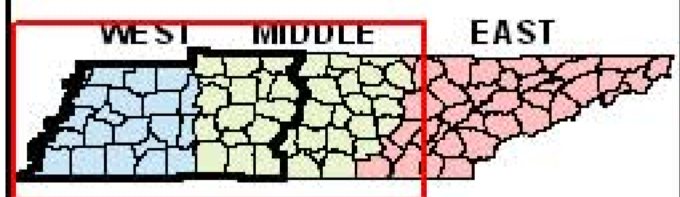
March 2008



State of Tennessee - Critical Counties (37)

County	No. of Functional Facilities	Total No. of Facilities
Benton	0	3
Carroll	0	6
Cheatham	3	3
Chester	0	2
Crockett	0	4
Davidson	23	23
Decatur	0	3
Dickson	4	4
Dyer	0	7
Fayette	0	7
Gibson	0	9
Giles	5	5
Hardeman	0	5
Hardin	0	3
Haywood	0	2
Henderson	0	3
Henry	0	4
Hickman	2	2
Houston	2	2

County	No. of Functional Facilities	Total No. of Facilities
Humphreys	3	4
Lake	0	3
Lauderdale	0	5
Lawrence	6	6
Lewis	2	2
Madison	0	3
Maury	4	4
Mc Nairy	0	4
Montgomery	5	5
Obion	0	7
Perry	0	1
Robertson	5	5
Shelby	0	39
Stewart	3	3
Tipton	0	6
Wayne	4	4
Weakley	0	7
Williamson	4	4



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Police Station Functionality

Day 1

- Non-Functional
- Functional
- Rivers
- Interstates
- Critical Counties
- US Routes

- West Region
- Middle Region
- East Region

0 12.5 25 50 75

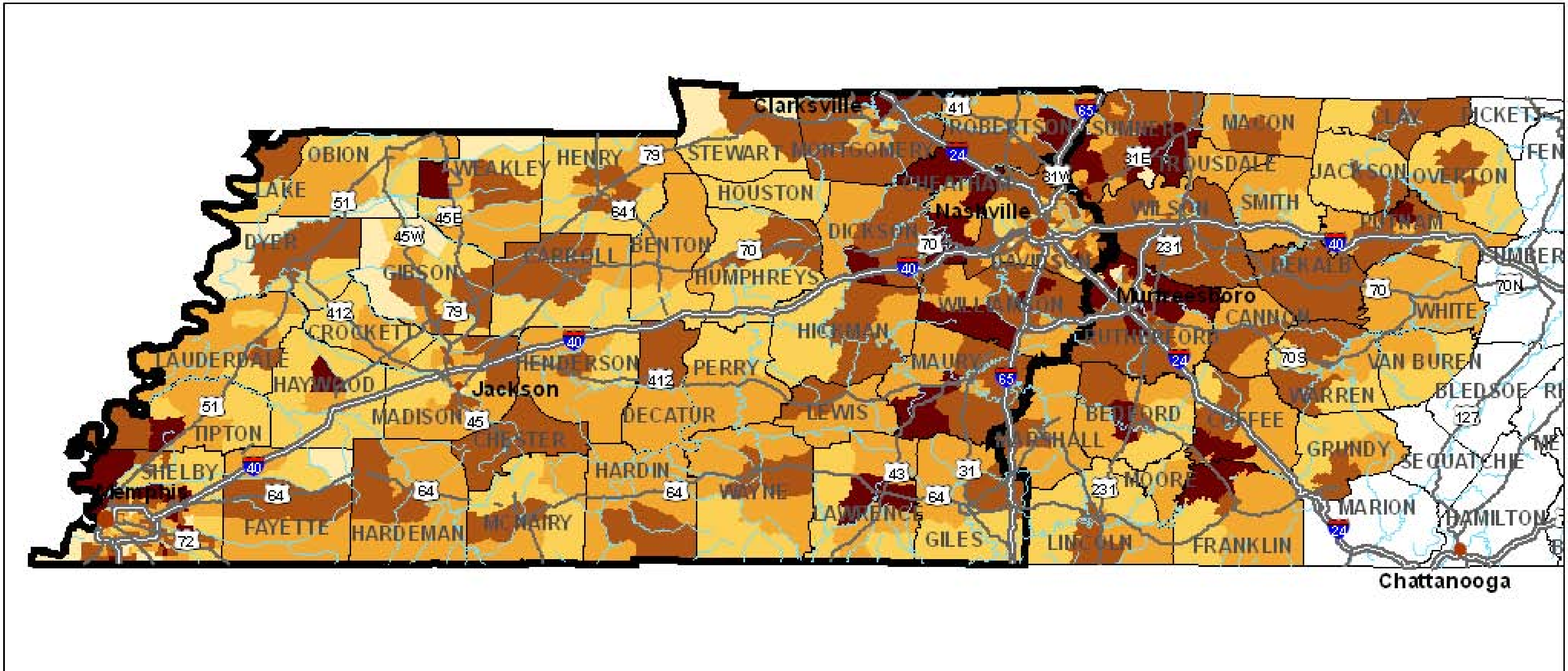
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

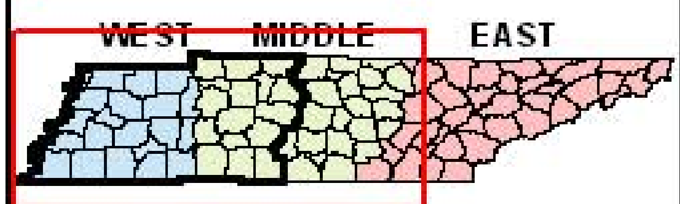
Total Population (2000) - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Population	County	Population	County	Population
Benton	16,537	Hardin	25,578	Maury	69,498
Carroll	29,475	Haywood	19,797	Montgomery	134,768
Cheatham	35,912	Henderson	25,522	Obion	32,450
Chester	15,540	Henry	31,115	Perry	7,631
Crockett	14,532	Hickman	22,295	Robertson	54,433
Davidson	569,891	Houston	8,088	Shelby	897,472
Decatur	11,731	Humphreys	17,929	Stewart	12,370
Dickson	43,156	Lake	7,954	Tipton	51,271
Dyer	37,279	Lauderdale	27,101	Wayne	16,842
Fayette	28,806	Lawrence	39,926	Weakley	34,895
Gibson	48,152	Lewis	11,367	Williamson	126,638
Giles	29,447	McNairy	24,653		
Hardeman	28,105	Madison	91,837		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Total Population (HAZUS - 2000)
- 0 - 1,500
- 1,501 - 3,000
- 3,001 - 5,000
- 5,001 - 8,000
- 8,001 - 16,200
- Rivers
- Interstates
- Critical Counties
- US Routes

Major Cities
- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000

0 12.5 25 50 75
Miles

Mid-America Earthquake Center

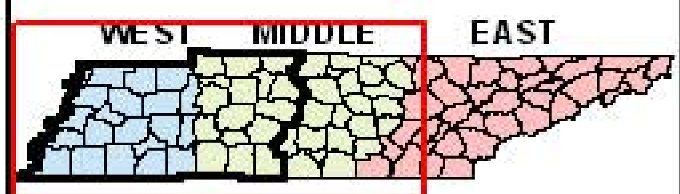
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Port Facility Damage - New Madrid Seismic Zone: M7.7 Event

March 2008

State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	0	0	0	Humphreys	11	0	0
Carroll	0	0	0	Lake	2	2	0
Cheatham	1	0	0	Lauderdale	5	5	5
Chester	0	0	0	Lawrence	0	0	0
Crockett	0	0	0	Lewis	0	0	0
Davidson	28	0	0	Madison	0	0	0
Decatur	5	0	0	Maury	0	0	0
Dickson	0	0	0	McNairy	0	0	0
Dyer	3	3	0	Montgomery	4	0	0
Fayette	0	0	0	Obion	0	0	0
Gibson	0	0	0	Perry	1	0	0
Giles	0	0	0	Robertson	0	0	0
Hardeman	0	0	0	Shelby	69	69	0
Hardin	5	0	0	Stewart	1	0	0
Haywood	0	0	0	Tipton	2	2	2
Henderson	0	0	0	Wayne	0	0	0
Henry	1	0	0	Weakley	0	0	0
Hickman	0	0	0	Williamson	0	0	0
Houston	0	0	0				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Port Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

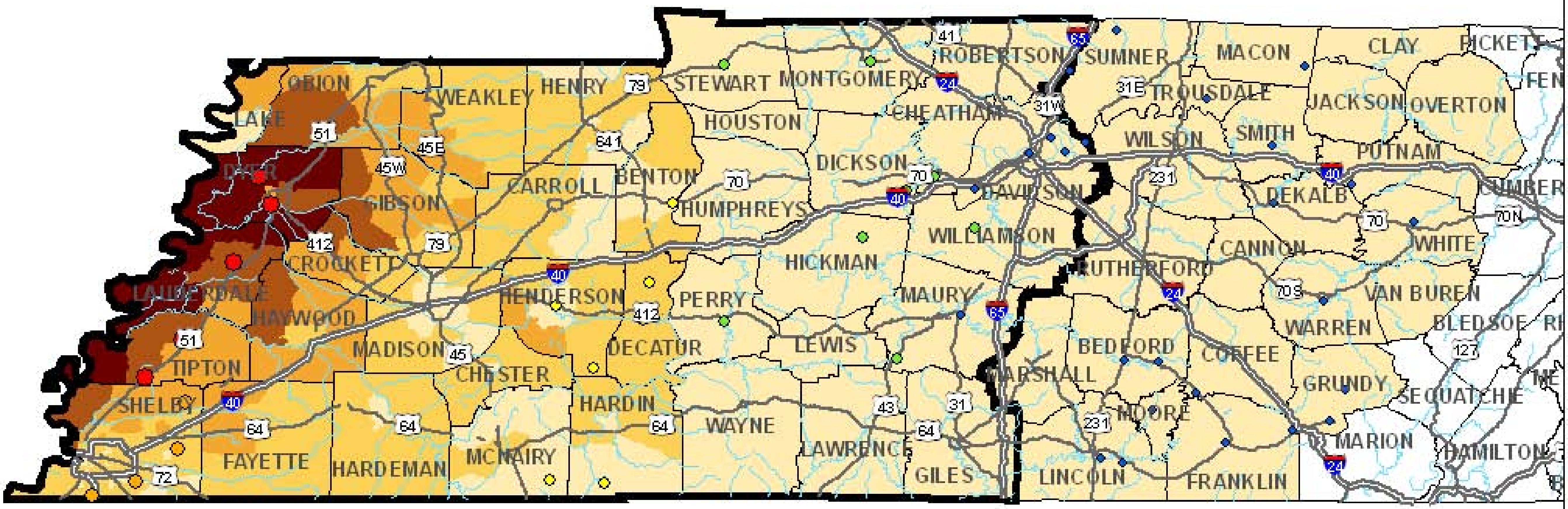
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

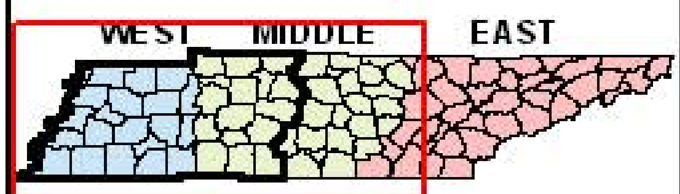
Potable Water System Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	1	0	0
Carroll	0	0	0
Cheatham	1	0	0
Chester	0	0	0
Crockett	0	0	0
Davidson	5	0	0
Decatur	2	0	0
Dickson	1	0	0
Dyer	2	2	1
Fayette	0	0	0
Gibson	0	0	0
Giles	0	0	0
Hardeman	0	0	0
Hardin	1	0	0
Haywood	0	0	0
Henderson	2	0	0
Henry	0	0	0
Hickman	1	0	0
Houston	0	0	0
Humphreys	0	0	0
Lake	0	0	0
Lauderdale	1	1	0
Lawrence	0	0	0
Lewis	0	0	0
Madison	0	0	0
Maury	2	0	0
McNairy	1	0	0
Montgomery	1	0	0
Obion	0	0	0
Perry	1	0	0
Robertson	0	0	0
Shelby	4	4	0
Stewart	1	0	0
Tipton	2	2	0
Wayne	0	0	0
Weakley	0	0	0
Williamson	1	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Potable Wate Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Rivers
Interstates
US Routes

Potable Water Distribution Lines

No. Leaks

0 - 10
10 - 50
50 - 200
200 - 500
500 - 1,000

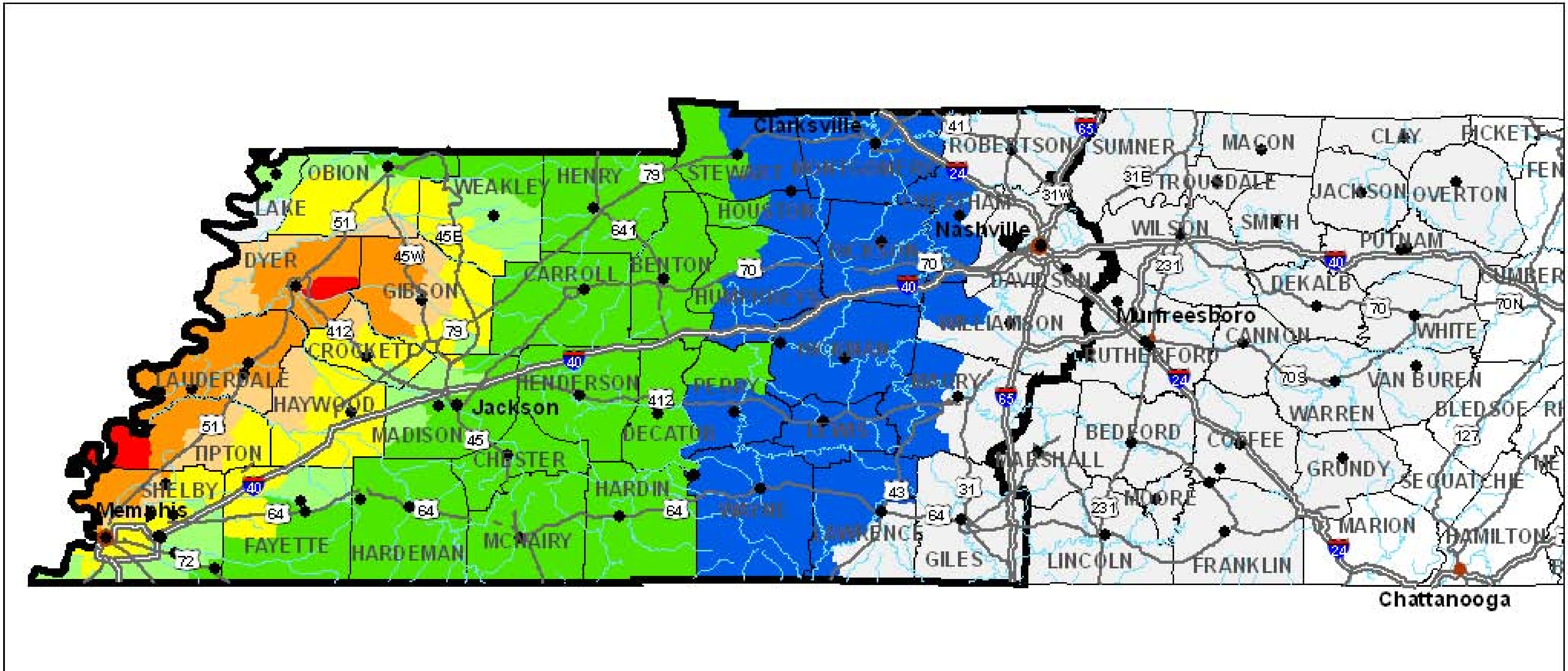
0 12.5 25 50 75
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

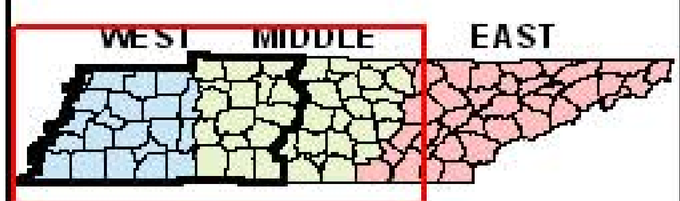
Prisons - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Facilities	County	No. of Facilities	County	No. of Facilities
Benton	1	Hardin	1	McNairy	1
Carroll	1	Haywood	1	Montgomery	1
Cheatham	1	Henderson	1	Obion	1
Chester	1	Henry	1	Perry	1
Crockett	1	Hickman	2	Robertson	1
Davidson	10	Houston	1	Shelby	10
Decatur	1	Humphreys	1	Stewart	1
Dickson	1	Lake	2	Tipton	1
Dyer	1	Lauderdale	3	Wayne	3
Fayette	2	Lawrence	1	Weakley	1
Gibson	1	Lewis	1	Williamson	1
Giles	1	Madison	3		
Hardeman	2	Maury	1		



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

- Prisons

Modified Mercalli Intensity (MMI)

- < VI
- VI
- VII
- VIII
- IX
- X
- XI
- XII

Major Cities

- 50,000 - 100,000
- 100,001 - 200,000
- 200,001 - 615,000
- Rivers
- Interstates
- Critical Counties
- US Routes

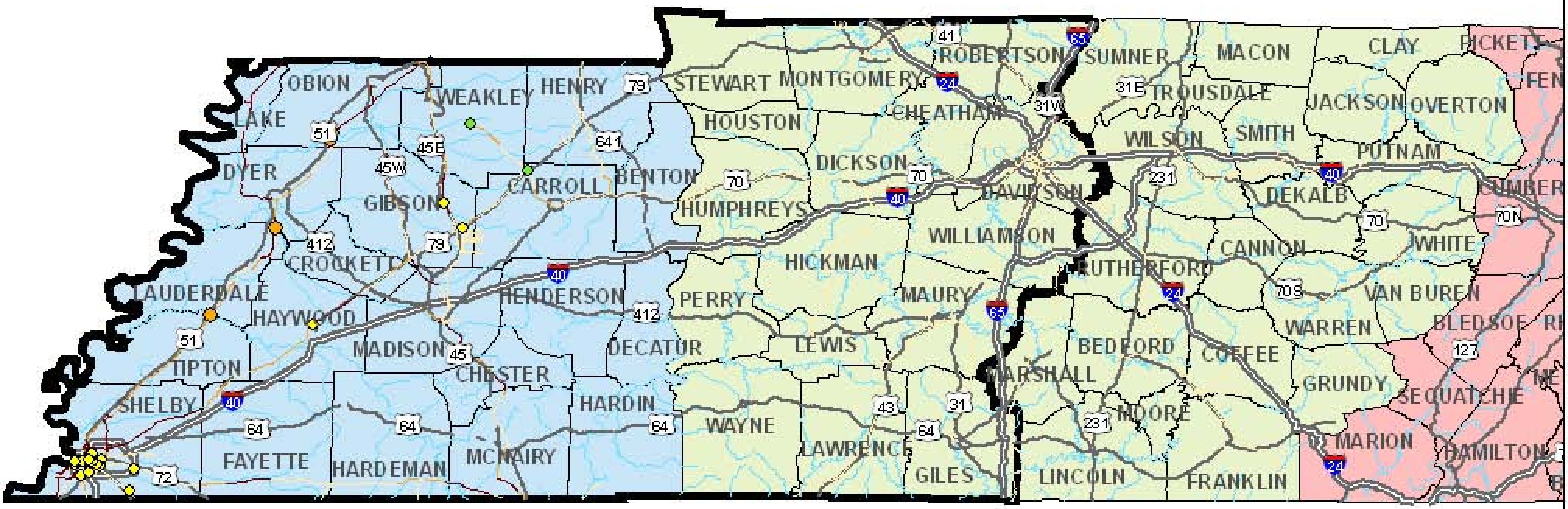
0 12.5 25 50 75 Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

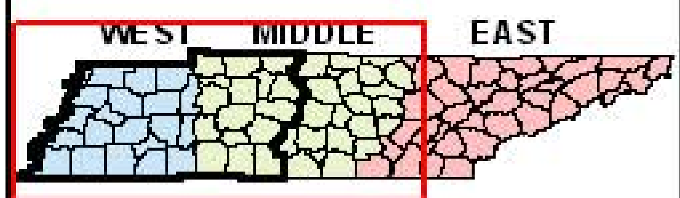
Railway Bridge & Segment Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	0	0	0	Humphreys	1	0	0
Carroll	1	0	0	Lake	0	0	0
Cheatham	0	0	0	Lauderdale	0	0	0
Chester	0	0	0	Lawrence	1	0	0
Crockett	0	0	0	Lewis	0	0	0
Davidson	23	0	0	Madison	0	0	0
Decatur	0	0	0	Maury	3	0	0
Dickson	3	0	0	McNairy	0	0	0
Dyer	1	1	0	Montgomery	2	0	0
Fayette	0	0	0	Obion	2	2	0
Gibson	2	0	0	Perry	0	0	0
Giles	2	0	0	Robertson	2	0	0
Hardeman	0	0	0	Shelby	27	0	0
Hardin	0	0	0	Stewart	0	0	0
Haywood	1	0	0	Tipton	1	1	0
Henderson	0	0	0	Wayne	0	0	0
Henry	0	0	0	Weakley	1	0	0
Hickman	1	0	0	Williamson	3	0	0
Houston	0	0	0				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Railway Bridge Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain
- West Region
- Middle Region
- East Region

Railway Segment Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Critical Counties
- Rivers
- Interstates
- US Routes

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

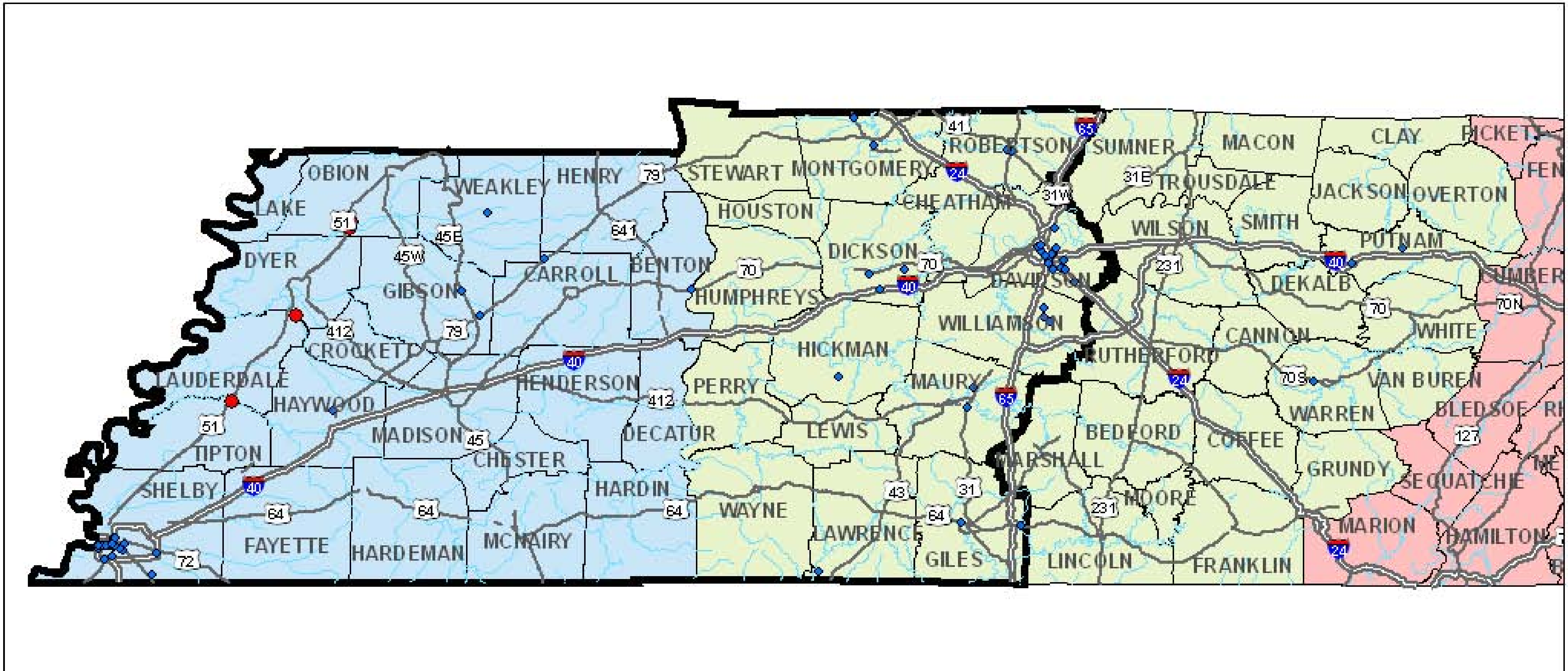
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigation

Railway Bridge Functionality - New Madrid Seismic Zone: M7.7 Event

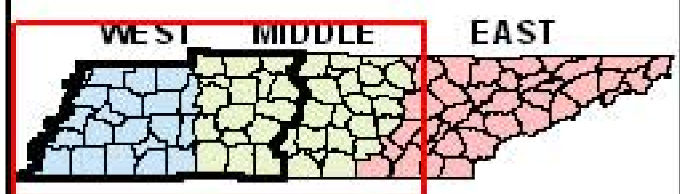
March 2008



State of Tennessee - Critical Counties (37)

County	No. of Functional Facilities	Total No. of Facilities
Benton	0	0
Carroll	1	1
Cheatham	0	0
Chester	0	0
Crockett	0	0
Davidson	23	23
Decatur	0	0
Dickson	3	3
Dyer	0	1
Fayette	0	0
Gibson	2	2
Giles	2	2
Hardeman	0	0
Hardin	0	0
Haywood	1	1
Henderson	0	0
Henry	0	0
Hickman	1	1
Houston	0	0

County	No. of Functional Facilities	Total No. of Facilities
Humphreys	1	1
Lake	0	0
Lauderdale	0	0
Lawrence	1	1
Lewis	0	0
Madison	0	0
Maury	3	3
Mc Nairy	0	0
Montgomery	2	2
Obion	0	2
Perry	0	0
Robertson	2	2
Shelby	27	27
Stewart	0	0
Tipton	0	1
Wayne	0	0
Weakley	1	1
Williamson	3	3



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Railway Bridge Functionality

Day 1

- Non-Functional
- Functional
- Rivers
- Interstates
- Critical Counties
- US Routes

- West Region
- Middle Region
- East Region

0 12.5 25 50 75

Miles

Mid-America Earthquake Center

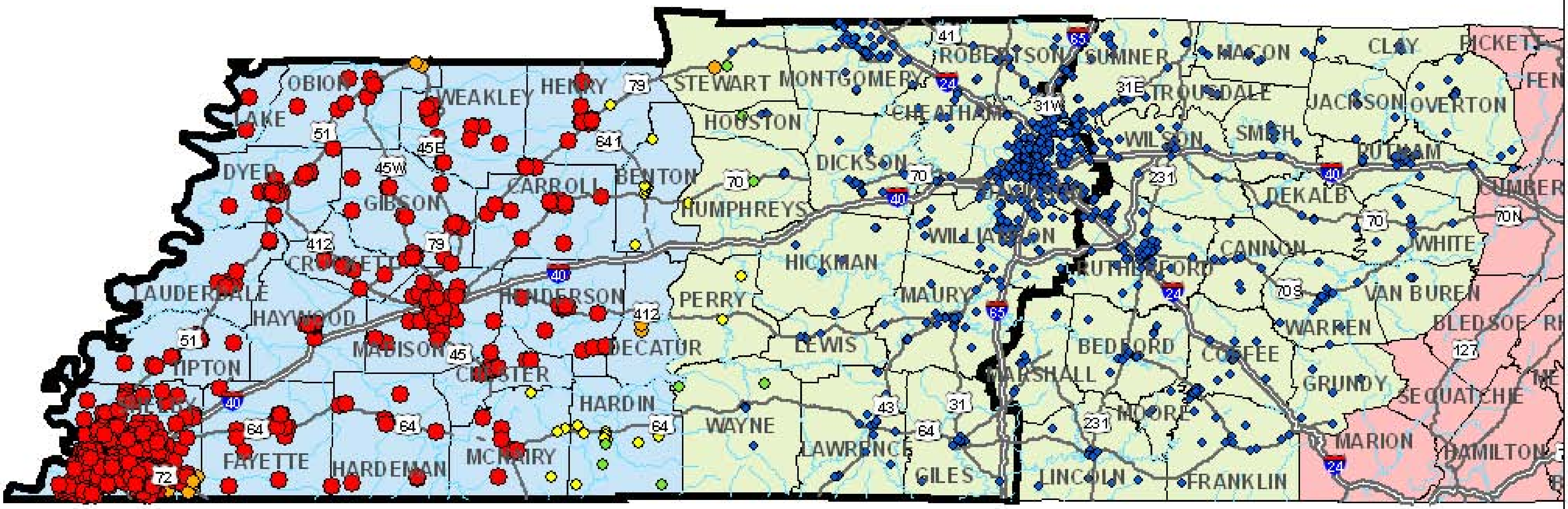
University of Illinois at Urbana-Champaign, Illinois, USA

Amr S. Elnashai, Project Principal Investigator

Theresa Jefferson, Principal Investigator

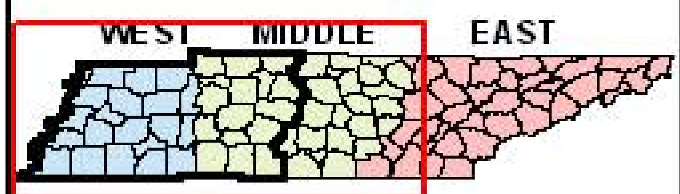
School Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage	County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	10	0	0	Humphreys	10	0	0
Carroll	18	18	0	Lake	3	3	1
Cheatham	15	0	0	Lauderdale	10	10	10
Chester	11	11	0	Lawrence	19	0	0
Crockett	7	7	7	Lewis	7	0	0
Davidson	205	0	0	Mc Nairy	12	8	0
Decatur	4	2	0	Madison	44	44	0
Dickson	19	0	0	Maury	26	0	0
Dyer	17	17	17	Montgomery	50	0	0
Fayette	14	14	4	Obion	11	11	4
Gibson	21	21	19	Perry	5	0	0
Giles	11	0	0	Robertson	22	0	0
Hardeman	14	14	0	Shelby	361	361	310
Hardin	13	0	0	Stewart	4	1	0
Haywood	8	8	8	Tipton	14	14	14
Henderson	13	13	0	Wayne	10	0	0
Henry	10	9	0	Weakley	16	16	10
Hickman	10	0	0	Williamson	57	0	0
Houston	5	0	0				



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

School Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

- Critical Counties
- Rivers
- Interstates
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

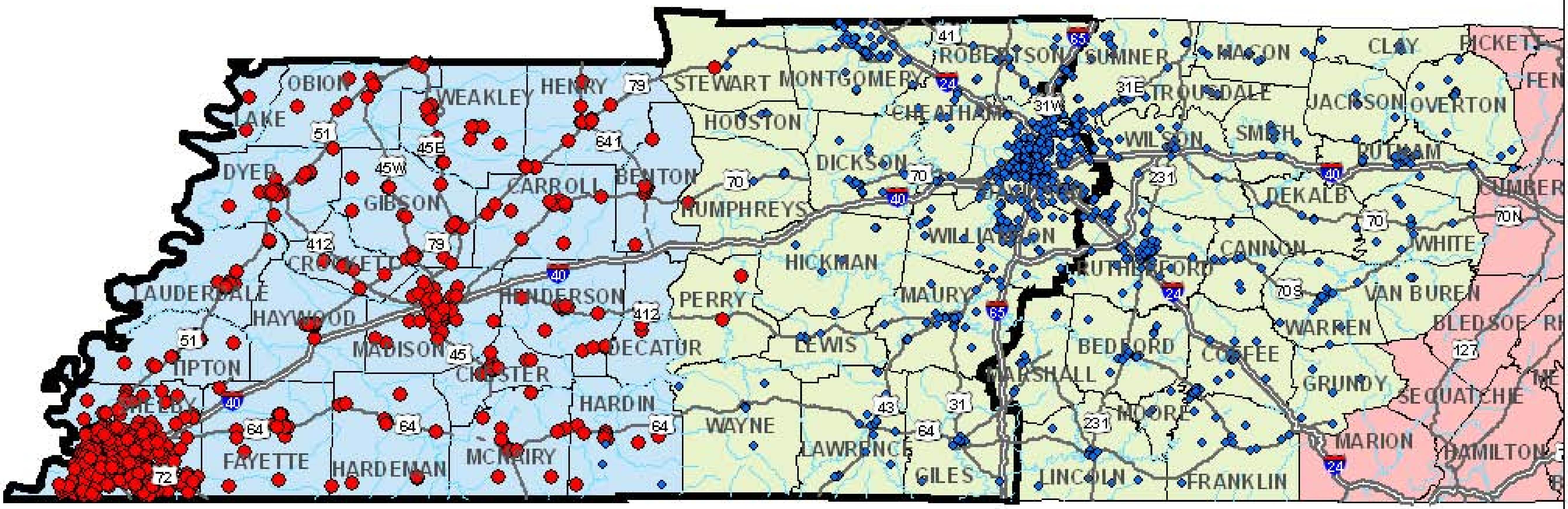
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

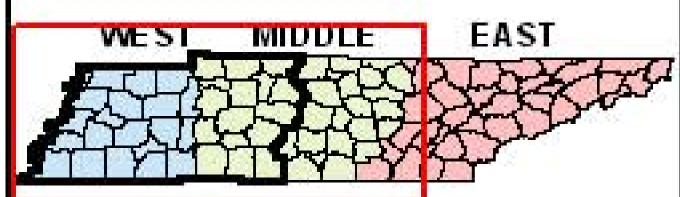
School Functionality - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	No. of Functional Facilities	Total No. of Facilities
Benton	0	10
Carroll	0	18
Cheatham	15	15
Chester	0	11
Crockett	0	7
Davidson	205	205
Decatur	0	4
Dickson	19	19
Dyer	0	17
Fayette	0	14
Gibson	0	21
Giles	11	11
Hardeman	0	14
Hardin	3	13
Haywood	0	8
Henderson	0	13
Henry	0	10
Hickman	10	10
Houston	5	5
Humphreys	9	10
Lake	0	3
Lauderdale	0	10
Lawrence	19	19
Lewis	7	7
Madison	0	44
Maury	26	26
McNairy	0	12
Montgomery	50	50
Obion	0	11
Perry	0	5
Robertson	22	22
Shelby	0	361
Stewart	3	4
Tipton	0	14
Wayne	10	10
Weakley	0	16
Williamson	57	57



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

School Functionality

Day 1

- Non-Functional
- Functional
- Rivers
- Interstates
- Critical Counties
- US Routes
- West Region
- Middle Region
- East Region

0 12.5 25 50 75

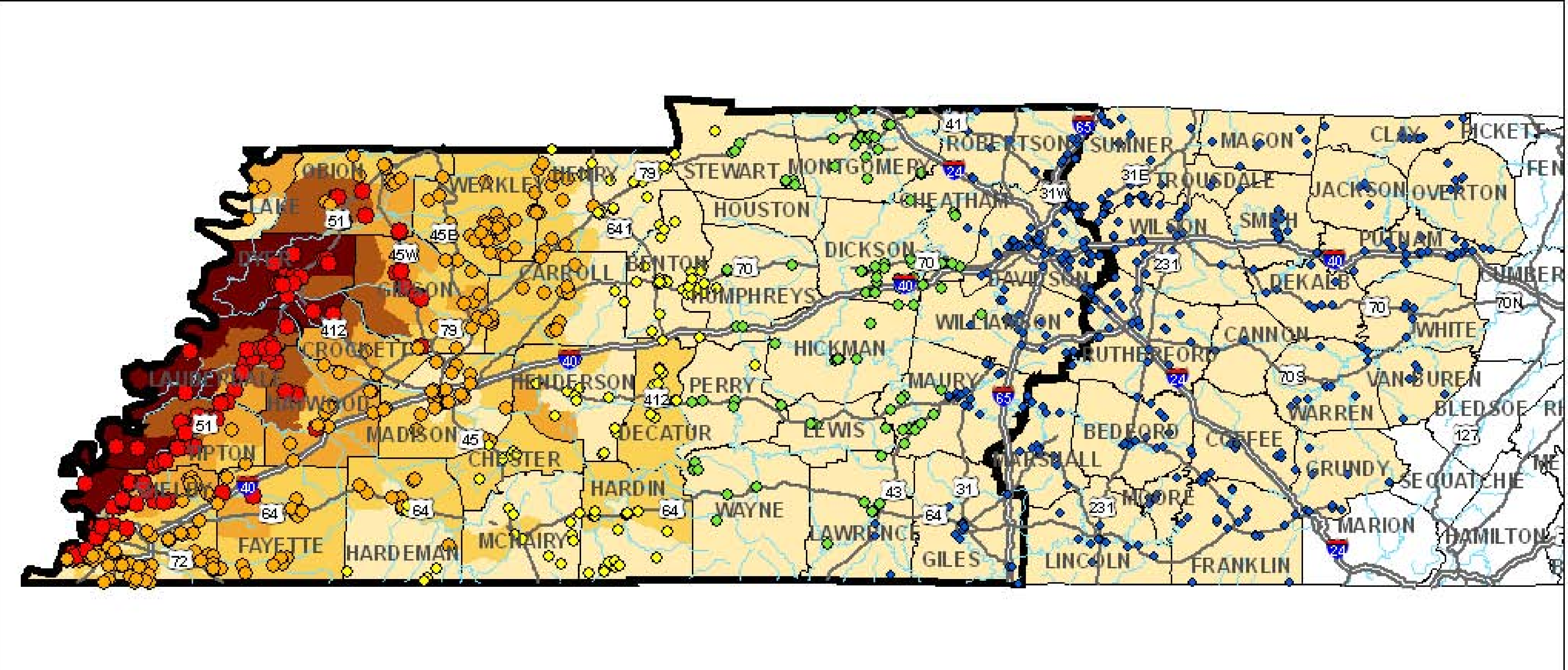
Miles

Mid-America Earthquake Center

University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

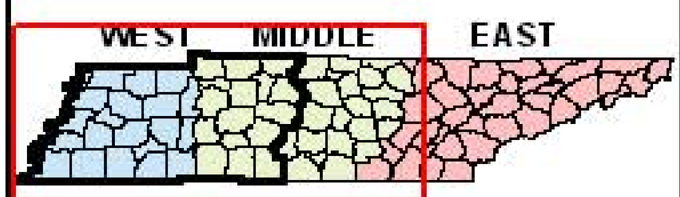
Waste Water System Damage - New Madrid Seismic Zone: M7.7 Event

March 2008



State of Tennessee - Critical Counties (37)

County	Total No. of Facilities	At Least Moderate Damage	Complete Damage
Benton	18	0	0
Carroll	22	20	0
Cheatham	10	0	0
Chester	6	0	0
Crockett	5	5	0
Davidson	64	0	0
Decatur	12	0	0
Dickson	16	0	0
Dyer	20	20	9
Fayette	18	18	0
Gibson	20	20	0
Giles	15	0	0
Hardeman	18	9	0
Hardin	18	0	0
Haywood	23	23	0
Henderson	13	1	0
Henry	28	10	0
Hickman	9	0	0
Houston	0	0	0
Humphreys	20	0	0
Lake	3	3	0
Lauderdale	15	15	3
Lawrence	9	0	0
Lewis	5	0	0
Madison	29	29	0
Maury	28	0	0
McNairy	10	0	0
Montgomery	22	0	0
Obion	21	21	0
Perry	7	0	0
Robertson	15	0	0
Shelby	117	117	0
Stewart	11	0	0
Tipton	26	26	2
Wayne	7	0	0
Weakley	38	38	0
Williamson	24	0	0



Critical counties are those that experience the greatest probability of reaching the specified damage state. For definitions of 'Complete' and 'At Least Moderate' damage states please consult the attached document, "GUIDE FOR IMPACT ASSESSMENT TERMINOLOGY."

Legend

Waste Water Facility Damage

At Least Moderate

- Highly Unlikely
- Unlikely
- Moderate Likelihood
- Highly Likely
- Certain

Critical Counties
Rivers
Interstates
US Routes

Waste Water Distribution Lines

No. of Leaks

- 0 - 10
- 10 - 50
- 50 - 150
- 150 - 300
- 300 - 800

0 12.5 25 50 75
Miles

Mid-America Earthquake Center
University of Illinois at Urbana-Champaign, Illinois, USA
Amr S. Elnashai, Project Principal Investigator
Theresa Jefferson, Principal Investigator

Appendix IX: Comparison with CUSEC Earthquake Impact Assessment

The purpose of this appendix is to provide comparative data points for the main analysis, and to verify that consistent results are being obtained in the Central US regions when undertaken by different groups. Moreover, the CUSEC analyses were used in the SONS07 workshops. Providing comparisons between CUSEC and the MAE Center-George Washington University study is necessary for the calibration of response measures intended to be employed by agencies involved in both SONS07 and the current FEMA-lead effort. All scenarios in this appendix employ the New Madrid Seismic Zone (NMSZ) southwest segment event. Liquefaction susceptibility data was included in this analysis, though all other impact assessment parameters remained at the default setting within the program. No scenarios were completed for the Wabash Valley Seismic Zone or the East Tennessee Seismic Zone earthquakes. As a result, no comparisons are made with the scenarios completed by the MAE Center in the investigation presented in the main body of the report. All scenarios discussed in this appendix refer to the NMSZ southwest segment event and results are shown for the critical counties only since the CUSEC analyses only include the areas identified as critical counties in this study.

Alabama

Table 1: Damage by General Occupancy for the State of Alabama

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	227,442	13,052	2,856	63	0	243,419
CUSEC	223,226	14,228	5,502	437	26	243,419

Table 2: Hospital Functionality for the State of Alabama

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	2,624	2,134	81.3	2,142	81.6	2,492	95.0	2,620	99.8	2,621	99.9
CUSEC	2,254	1,821	80.8	1,826	81.0	2,080	92.3	2,238	99.3	2,243	99.5

Table 3: Households without Potable Water for the State of Alabama

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	248,471	0	0	0	0	0
CUSEC	248,471	0	0	0	0	0

Table 4: Damage to Potable Water Facilities for the State of Alabama

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	7	0	0
CUSEC	7	0	0

Table 5: Damage to Potable Water Pipelines for the State of Alabama

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	20,629	152	37
CUSEC	33,222	112	28

Table 6: Electrical Power System Performance for the State of Alabama

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	248,471	0	0	0	0	0
CUSEC	248,471	0	0	0	0	0

Table 7: Damage to Waste Water Facilities for the State of Alabama

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	63	3	0
CUSEC	42	1	0

Table 8: Damage to Waste Water Pipelines for the State of Alabama

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	12,378	121	30
CUSEC	19,933	88	22

Table 9: Damage to Highway Bridges

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	2,366	18	1
CUSEC	1,935	13	0

Table 10: Debris Summary Report for the State of Alabama

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	32.7	12.2	45.0
CUSEC	53.0	26.0	78.0

Table 11: Shelter Requirements for the State of Alabama

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	27	5
CUSEC	89	25

Table 12: Worst Case Casualties for the State of Alabama

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury- Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (5PM)	29	1	0	0	30
CUSEC (2AM)	64	7	0	1	72

Table 13: Total Direct Economic Losses for the State of Alabama

System	MAEC	CUSEC
Buildings	$264,939,000	$129,322,000
Transportation	$19,734,000	$9,340,000
Utility	$175,662,000	$28,514,000
Total	**$460,335,000**	**$167,176,000**

Arkansas

Table 14: Damage by General Occupancy for the State of Arkansas

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	368,648	83,427	41,327	18,332	50,159	561,893
CUSEC	359,205	84,171	49,306	16,428	52,796	561,906

Table 15: Hospital Functionality for the State of Arkansas

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	7,222	3,101	42.9	3,130	43.3	4,395	60.9	5,719	79.2	5,978	82.8
CUSEC	6,979	3,246	46.5	3,268	46.8	4,175	59.8	5,515	79.0	5,850	83.8

Table 16: Households without Potable Water for the State of Arkansas

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	519,225	175,565	174,382	171,216	132,671	79,736
CUSEC	519,225	176,151	175,059	172,140	134,692	92,600

Table 17: Damage to Potable Water Facilities for the State of Arkansas

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	31	7	1
CUSEC	31	6	1

Table 18: Damage to Potable Water Pipelines for the State of Arkansas

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	85,192	19,309	29,673
CUSEC	85,195	19,983	32,239

Table 19: Electrical Power System Performance for the State of Arkansas

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	519,225	95,309	68,562	39,397	13,540	113
CUSEC	519,225	96,438	70,923	42,544	15,291	112

Table 20: Damage to Waste Water Facilities for the State of Arkansas

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	229	90	23
CUSEC	229	90	24

Table 21: Damage to Waste Water Pipelines for the State of Arkansas

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	51,117	15,267	23,467
CUSEC	51,117	15,805	25,498

Table 22: Damage to Highway Bridges for the State of Arkansas

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	2,883	775	512
CUSEC	2,879	287	167

Table 23: Debris Summary Report for the State of Arkansas

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	3,361	3,708	7,069
CUSEC	3,526	3,624	7,150

Table 24: Shelter Requirements for the State of Arkansas

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	126,987	37,244
CUSEC	47,694	13,865

Table 25: Worst Case Casualties for the State of Arkansas

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (2AM)	8,883	2,648	409	742	12,682
CUSEC (2AM)	10,847	2,963	330	612	14,751

Table 26: Total Direct Economic Losses for the State of Arkansas

System	MAEC	CUSEC
Buildings	$12,533,364,000	$11,681,053,000
Transportation	$1,946,586,000	$1,977,353,000
Utility	$3,794,526,000	$4,142,127,000
Total	**$18,274,476,000**	**$17,800,533,000**

Illinois

Table 27: Damage by General Occupancy for the State of Illinois

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	352,043	48,140	20,321	5,711	16,857	443,072
CUSEC	402,264	24,818	10,204	1,521	4,267	443,074

Table 28: Hospital Functionality for the State of Illinois

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	6,814	4,202	61.7	4,224	62.0	5,186	76.1	6,113	89.7	6,312	92.6
CUSEC	5,796	4,782	82.5	4,793	82.7	5,212	89.9	5,577	96.2	5,639	97.3

Table 29: Households without Potable Water for the State of Illinois

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	524,859	69,661	48,146	24,347	6,672	76
CUSEC	524,859	20,357	17,003	10,781	0	0

Table 30: Damage to Potable Water Facilities for the State of Illinois

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	74	18	3
CUSEC	74	3	0

Table 31: Damage to Potable Water Pipelines for the State of Illinois

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	79,646	4,857	5,243
CUSEC	79,646	610	1,491

Table 32: Electrical Power System Performance for the State of Illinois

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	524,859	69,641	48,139	24,340	6,678	83
CUSEC	524,859	0	0	0	0	0

Table 33: Damage to Waste Water Facilities for the State of Illinois

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	2,221	642	78
CUSEC	300	18	1

Table 34: Damage to Waste Water Pipelines for the State of Illinois

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	47,788	3,842	4,147
CUSEC	47,788	483	1,179

Table 35: Damage to Highway Bridges for the State of Illinois

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	6,554	432	242
CUSEC	6,554	106	57

Table 36: Debris Summary Report for the State of Illinois

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	1,214	1,143	2,358
CUSEC	385	285	669

Table 37: Shelter Requirements for the State of Illinois

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	51,381	14,706
CUSEC	5,042	1,376

Table 38: Worst Case Casualties for the State of Illinois

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (2AM)	4,478	1,236	146	276	6,136
CUSEC (2AM)	1,074	277	30	56	1,438

Table 39: Total Direct Economic Losses for the State of Illinois

System	MAEC	CUSEC
Buildings	$4,868,224,000	$1,246,257,000
Transportation	$841,922,000	$267,402,000
Utility	$25,372,048,000	$678,455,000
Total	**$31,082,194,000**	**$2,192,114,000**

Indiana

Table 40: Damage by General Occupancy for the State of Indiana

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	141,978	14,010	3,281	135	1	159,414
CUSEC	147,672	8,063	2,901	377	401	159,414

Table 41: Hospital Functionality for the State of Indiana

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	2,101	1,347	64.1	1,354	64.4	1,690	80.4	1,995	95.0	2,009	95.6
CUSEC	2,012	1,720	85.5	1,724	85.7	1,867	92.8	1,984	98.6	1,998	99.3

Table 42: Households without Potable Water for the State of Indiana

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	188,251	44,112	34,801	11,073	0	0
CUSEC	188,251	2	0	0	0	0

Table 43: Damage to Potable Water Facilities for the State of Indiana

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	16	1	0
CUSEC	16	0	0

Table 44: Damage to Potable Water Pipelines for the State of Indiana

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	22,653	221	597
CUSEC	22,654	74	49

Table 45: Electrical Power System Performance for the State of Indiana

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	188,251	0	0	0	0	0
CUSEC	188,251	0	0	0	0	0

Table 46: Damage to Waste Water Facilities for the State of Indiana

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	52	3	0
CUSEC	52	0	0

Table 47: Damage to Waste Water Pipelines for the State of Indiana

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	13,594	172	469
CUSEC	13,592	59	39

Table 48: Damage to Highway Bridges for the State of Indiana

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	2,214	76	14
CUSEC	2,214	2	0

Table 49: Debris Summary Report for the State of Indiana

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	107.3	64.7	172.0
CUSEC	98.0	59.0	158.0

Table 50: Shelter Requirements for the State of Indiana

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	52	13
CUSEC	549	141

Table 51: Worst Case Casualties for the State of Indiana

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (5PM)	57	12	12	2	84
CUSEC (2AM)	143	31	3	6	183

Table 52: Total Direct Economic Losses for the State of Indiana

System	MAEC	CUSEC
Buildings	$348,068,000	$230,130,000
Transportation	$69,853,000	$20,278,000
Utility	$430,017,000	$34,521,000
Total	**$847,938,000**	**$284,929,000**

Kentucky

Table 53: Damage by General Occupancy for the State of Kentucky

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	135,946	27,878	32,403	17,297	28,891	242,337
CUSEC	179,147	25,914	14,468	5,203	17,618	242,350

Table 54: Hospital Functionality for the State of Kentucky

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	3,312	1,314	39.7	1,323	39.9	1,685	50.9	2,131	64.3	2,271	68.6
CUSEC	3,112	2,155	69.2	2,162	69.5	2,408	77.4	2,708	87.0	2,792	89.7

Table 55: Households without Potable Water for the State of Kentucky

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	256,132	80,808	65,328	39,301	14,371	0
CUSEC	253,853	75,168	71,778	64,250	14,039	0

Table 56: Damage to Potable Water Facilities for the State of Kentucky

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	36	14	2
CUSEC	36	4	0

Table 57: Damage to Potable Water Pipelines for the State of Kentucky

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	35,884	7,351	7,116
CUSEC	35,884	1,757	4,728

Table 58: Electrical Power System Performance for the State of Kentucky

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	256,132	51,079	37,329	20,113	5,613	58
CUSEC	253,853	7,333	4,590	2,174	700	9

Table 59: Damage to Waste Water Facilities for the State of Kentucky

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	1,561	661	170
CUSEC	93	17	2

Table 60: Damage to Waste Water Pipelines for the State of Kentucky

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	21,532	5,813	5,631
CUSEC	21,530	1,390	3,740

Table 61: Damage to Highway Bridges for the State of Kentucky

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	2,173	368	203
CUSEC	2,082	132	82

Table 62: Debris Summary Report for the State of Kentucky

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	2,136	2,337	4,473
CUSEC	1,100	1,144	2,244

Table 63: Shelter Requirements for the State of Kentucky

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	52,964	13,904
CUSEC	18,168	4,925

Table 64: Worst Case Casualties for the State of Kentucky

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (2PM)	6,722	2,051	318	593	12,584
CUSEC (2AM)	3,463	932	96	176	4,667

Table 65: Total Direct Economic Losses for the State of Kentucky

System	MAEC	CUSEC
Buildings	$9,221,413,000	$4,218,542,000
Transportation	$990,682,000	$880,577,000
Utility	$23,302,503,000	$716,440,000
Total	**$33,524,598,000**	**$5,815,559,000**

Mississippi

Table 66: Damage by General Occupancy for the State of Mississippi

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	167,551	61,934	23,844	11,399	7,300	272,027
CUSEC	166,536	52,522	28,283	8,342	16,362	272,045

Table 67: Hospital Functionality for the State of Mississippi

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	2,659	779	29.3	790	29.7	1,272	47.8	1,959	73.7	2,174	81.8
CUSEC	3,312	1,314	39.7	1,326	40.0	1,778	53.7	2,547	76.9	2,798	84.5

Table 68: Households without Potable Water for the State of Mississippi

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	275,342	41,790	40,256	39,752	28,749	0
CUSEC	275,342	62,670	61,956	59,729	35,492	0

Table 69: Damage to Potable Water Facilities for the State of Mississippi

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	3	1	0
CUSEC	3	0	0

Table 70: Damage to Potable Water Pipelines for the State of Mississippi

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	31,053	2,448	2,566
CUSEC	50,006	2,223	4,093

Table 71: Electrical Power System Performance for the State of Mississippi

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	275,342	32,601	18,416	6,452	1,276	44
CUSEC	275,342	8,685	4,944	2,011	607	12

Table 72: Damage to Waste Water Facilities for the State of Mississippi

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	630	176	8
CUSEC	116	20	1

Table 73: Damage to Waste Water Pipelines for the State of Mississippi

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	30,007	1,935	2,030
CUSEC	30,004	1,758	3,237

Table 74: Damage to Highway Bridges for the State of Mississippi

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	5,043	300	100
CUSEC	4,032	233	122

Table 75: Debris Summary Report for the State of Mississippi

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	905	1,288	2,193
CUSEC	1,166	1,259	2,425

Table 76: Shelter Requirements for the State of Mississippi

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	20,832	5,555
CUSEC	15,086	3,926

Table 77: Worst Case Casualties for the State of Mississippi

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (2PM)	2,036	474	45	86	2,646
CUSEC (2AM)	3,484	878	81	145	4,588

Table 78: Total Direct Economic Losses for the State of Mississippi

System	MAEC	CUSEC
Buildings	$3,591,980,000	$4,213,844,000
Transportation	$224,612,000	$321,705,000
Utility	$4,659,756,000	$580,516,000
Total	**$8,476,348,000**	**$5,116,065,000**

Missouri

Table 79: Damage by General Occupancy for the State of Missouri

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	780,084	81,136	32,675	13,456	36,889	944,241
CUSEC	831,862	59,568	25,692	6,418	20,729	944,269

Table 80: Hospital Functionality for the State of Missouri

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	15,023	9,875	65.7	9,926	66.1	11,985	79.8	13,988	93.1	14,164	94.3
CUSEC	12,648	9,826	77.7	9,853	77.9	10,825	85.6	11,767	93.0	11,944	94.4

Table 81: Households without Potable Water for the State of Missouri

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	1,184,976	146,376	115,385	79,849	77,817	38,425
CUSEC	1,184,976	93,066	87,846	78,000	66,313	38,744

Table 82: Damage to Potable Water Facilities for the State of Missouri

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	3,413	843	179
CUSEC	52	13	3

Table 83: Damage to Potable Water Pipelines for the State of Missouri

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	71,169	13,501	20,020
CUSEC	114,598	9,539	17,003

Table 84: Electrical Power System Performance for the State of Missouri

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	1,184,976	100,141	70,719	39,500	12,957	119
CUSEC	1,184,976	40,254	28,491	16,897	6,326	49

Table 85: Damage to Waste Water Facilities for the State of Missouri

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	605	107	21
CUSEC	626	54	11

Table 86: Damage to Waste Water Pipelines for the State of Missouri

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	42,698	10,674	15,837
CUSEC	68,759	7,544	13,448

Table 87: Damage to Highway Bridges for the State of Missouri

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	7,803	1,306	879
CUSEC	7,803	800	564

Table 88: Debris Summary Report for the State of Missouri

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	3,171	3,386	6,565
CUSEC	1,750	1,575	3,325

Table 89: Shelter Requirements for the State of Missouri

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	121,927	28,999
CUSEC	25,215	7,292

Table 90: Worst Case Casualties for the State of Missouri

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (2AM)	11,267	3,177	401	760	15,605
CUSEC (2AM)	5,871	1,614	193	364	8,042

Table 91: Total Direct Economic Losses for the State of Missouri

System	MAEC	CUSEC
Buildings	$11,690,440,000	$5,528,119,000
Transportation	$1,727,420,000	$1,200,249,000
Utility	$24,502,340,000	$2,886,090,000
Total	**$37,920,200,000**	**$9,614,458,000**

Tennessee

Table 92: Damage by General Occupancy for the State of Tennessee

	Green (None)	Green (Slight)	Green (Moderate)	Yellow (Extensive)	Red (Complete)	Total
MAEC	495,284	192,666	131,358	42,367	81,907	943,580
CUSEC	609,392	128,847	67,201	22,572	115,591	943,603

Table 93: Hospital Functionality for the State of Tennessee

	Total # of Beds	Day 1		Day 3		Day 7		Day 30		Day 90	
		# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%	# of Beds	%
MAEC	15,351	7,018	45.7	7,053	45.9	8,311	54.1	11,821	77.0	12,884	83.9
CUSEC	12,002	5,566	46.4	5,592	46.6	6,533	54.4	8,299	69.1	9,093	75.8

Table 94: Households without Potable Water for the State of Tennessee

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	1,041,220	446,873	433,653	408,184	360,565	164,784
CUSEC	1,041,220	533,925	531,864	526,080	424,725	317,321

Table 95: Damage to Potable Water Facilities for the State of Tennessee

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	30	12	3
CUSEC	30	8	2

Table 96: Damage to Potable Water Pipelines for the State of Tennessee

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	49,280	18,539	12,242
CUSEC	79,354	11,419	24,050

Table 97: Electrical Power System Performance for the State of Tennessee

	# of Households	At day 1	At day 3	At day 7	At day 30	At day 90
MAEC	1,041,220	426,576	296,234	146,292	37,714	507
CUSEC	1,041,220	262,730	162,971	76,363	24,269	341

Table 98: Damage to Waste Water Facilities for the State of Tennessee

	# of Facilities	At Least Moderate Damage	Complete Damage
MAEC	742	366	76
CUSEC	188	70	15

Table 99: Damage to Waste Water Pipelines for the State of Tennessee

	Length (miles)	Total Number of Leaks	Total Number of Breaks
MAEC	29,568	14,662	9,683
CUSEC	47,613	9,032	19,021

Table 100: Damage to Highway Bridges for the State of Tennessee

	# of Bridges	At Least Moderate Damage	Complete Damage
MAEC	3,815	953	567
CUSEC	2,815	674	444

Table 101: Debris Summary Report for the State of Tennessee

	Brick, Wood & Others (Thousands of Tons)	Concrete & Steel (Thousands of Tons)	Total (Thousands of Tons)
MAEC	8,767	11,846	20,613
CUSEC	7,554	8,282	15,836

Table 102: Shelter Requirements for the State of Tennessee

	No. of Displaced Residences	No. People Needing Short-Term Shelter
MAEC	262,907	73,293
CUSEC	129,869	36,454

Table 103: Worst Case Casualties for the State of Tennessee

	Level I (Minor Injury)	Level II (Moderate Injury - Delayed Attention)	Level III (Severe Injury - Immediate Attention)	Level IV (Fatality)	Total Casualties
MAEC (2PM)	31,913	9,706	1,544	2,904	46,067
CUSEC (2PM)	25,692	7,696	1,182	2,183	36,752

Table 104: Total Direct Economic Losses for the State of Tennessee

System	MAEC	CUSEC
Buildings	$40,192,166,000	$30,557,641,000
Transportation	$1,645,129,000	$2,181,371,000
Utility	$14,221,248,000	$2,941,503,000
Total	**$56,058,543,000**	**$35,680,515,000**

This report is the outcome of one of the largest and most comprehensive earthquake consequence assessment projects funded by the Federal Emergency Management Agency (FEMA). The report contains earthquake impact assessments for the 8 central US (CUSEC) states. It reports damage and other consequences to the built environment as well as social and economic impacts. The earthquake scenarios used represent the New Madrid, the Wabash Valley and the East Tennessee seismic zones. The analysis employs new and more reliable hazard and inventory data that has not been used before. The work was undertaken in partnership with the Institute for Crisis, Disaster and Risk Management at the George Washington University, with contributions for the 8 State Geological Surveys, IEM, FEMA, US Geological Survey and the Central US Earthquake Consortium.

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